North Peoria Area Drainage Master Plan

Prepared for the
Flood Control District
of Maricopa County

FLOOD CONTROL DISTRICT of MARICOPA COUNTY 1959

and the
City of Peoria

CITY OF PEORIA

Project No. 82000146
Contract FCD 99-45

Overview

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PREFACE

At the request of the City of Peoria, the Flood Control District of Maricopa County (District), under the authority of Arizona Revised Statutes Title 48, Chapter 21, initiated the North Peoria Area Drainage Master Plan (North Peoria ADMP). The North Peoria ADMP is a regional approach to watershed management. The District prefers a regional approach to watershed and floodplain management because it enables the District to develop flood control strategies that are both sustainable and sensitive to the environment. This approach works to minimize the public cost of protecting citizens from flooding that may result from private and public development's cumulative effect on drainage characteristics. The North Peoria ADMP provides a uniform and coordinated approach to watershed management. A multi-faceted approach will ensure that present and future residents are protected from the damaging effects of flooding.

The North Peoria ADMP study area encompasses approximately 73 square miles within unincorporated Maricopa County and the City of Peoria. Numerous watersheds drain the area to the Agua Fria River. Major ***watercourses*** draining to the Agua Fria River are Morgan City Wash, nine unnamed washes, Caterpillar Tank Wash, and Twin Buttes Wash. Approximately 66 linear miles of ***watercourses*** are considered in the development of the North Peoria ADMP.

Within non-urbanized / rural watersheds natural environmental hazards associated with runoff from storm events exist. Without sufficient planning and management, natural hazards are compounded as development occurs within a watershed. In order to protect private and public property, natural occurring environmental hazards and hazards created by urbanization are identified. Environmental hazards associated with storm runoff are categorized into flood hazards and ***erosion*** hazards. As part of the North Peoria ADMP, approximately 36 linear miles of new floodplain delineation and 54 miles of ***erosion*** hazard zone delineation was conducted.

The North Peoria ADMP provides a regional approach to flood control management. Development of flood control management alternatives and policies that form the foundation of the plan takes into account engineering, environmental, landscape, social, and economic considerations. Watershed management alternatives are developed to mitigate / minimize the effect of urbanization on stormwater runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. The primary purpose for flood control management alternative development and evaluation is to develop a range of plans that provide public safety from flood and ***erosion*** hazards, determine the cost and benefits of each alternative, qualitatively determine impacts of the alternative on identified environmental resources, and select a preferred management plan.

Flood control management alternatives developed and evaluated for the North Peoria ADMP are categorized into two groups, ***watercourse*** management alternatives and stormwater storage alternatives. Watercourse management alternatives evaluated include a non-structural, a partial structural, a low impact structural, a full structural, and a no action. Stormwater storage alternatives evaluated include the standard practice of retaining the volume of flow from the 100-year, 2-hour event, in-stream, in-line detention alternative and an in-stream, off-line retention alternative Descriptions of the five ***z*** management alternatives evaluated are:

The full structural alternative is based on current federal, state and local floodplain management regulations that allow encroachment into the ***floodway fringe***. The full structural alternative typically requires at a minimum, structural stabilization of wash side slopes for the entire reach.

The partial structural alternative also is based on current floodplain management regulations, however the partial structural solution is applied at only specific locations along the ***watercourse***.

The low impact structural alternative allows for development activity to occur within the ***erosion*** hazard zone as long as the activity does not significantly alter the natural form and function of the ***watercourse***.

The non-structural alternative defines a corridor that allows the ***watercourse*** to function naturally.

The no action (do nothing) alternative provides flood control management based on current federal, state, and local floodplain management regulations that allows encroachment into the ***floodway fringe***. Typically, under current regulations encroachments into the ***floodway fringe*** are allowed on a piece-meal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire ***watercourse***.

Flood control management alternatives are evaluated on how well each alternative meets the goals of the North Peoria ADMP. The evaluations of the alternatives are based on weighted elements of four criteria. The criteria are Public Safety, Social Impacts, Environmental Impacts, and Economic Impacts. Preferred alternatives selected for the plan are based on the overall score that an alternative receives in the evaluation process relative to the other alternatives evaluated.

The preferred ***watercourse*** management flood control management alternative recommended by the plan is the non-structural alternative. The non-structural alternative defines a corridor that allows the ***watercourse*** to function naturally and is defined by the ***100-year floodplain***, ***erosion*** hazard zone, and a buffer, if applicable, between human activity and a wash corridor. The plan recognizes that there may be situations in which development activities may be required or desired within the ***erosion*** hazard zone. For this situation the plan presents a low impact structural alternative. Channelization is not a preferred flood control management alternative, however the plan also recognizes that there may be situations in which channelization may be required. The preferred stormwater storage alternative is the standard practice of retaining the volume from the 100-year, 2-hour rainfall event, however this practice may not be practical for certain portions of the study area. The standard retention practices, if implemented within an entire watershed, would have negative impacts in regards to sustaining native vegetation along ***watercourses***. The plan offers two alternatives to the standard practice, which are the in-stream, off-line retention and in-stream, in-line detention. The in-stream, off-line retention is the preferred alternative of the two.

Implementation of and guidance provided by the plan is based on a set of management goals, objectives, and policies for each of the four elements of the plan. The elements are Environmental Hazard Identification, Development & Planning Considerations, Environmental, and Multiple-Use Opportunities.

The North Peoria ADMP is one of the many tools that have been developed to guide growth and development in the study area so that impacts of urbanization on the environment are minimized. The focus of the North Peoria ADMP is flood and ***erosion*** control management, however the plan takes into consideration the impacts of different flood control management alternatives on environmental, cultural, and visual resources and looks at multi-use opportunities. The intent of this plan is to work in conjunction with other planning documents and ordinances developed by the City of Peoria and Maricopa County. The plan is to be used by policy makers in the City of Peoria and Maricopa County, future residents, and developers when making decisions concerning development in the area.

Acknowledgements

The success of developing this document is attributed to the many individuals who contributed their professional expertise and shared belief that with appropriate planning, public safety and quality of life can be maintained for the citizens of Maricopa County and the City of Peoria. Our sincere appreciation is extended to the following governmental bodies, agencies, individuals, and consultants for their help and perspective while developing the North Peoria Area Drainage Master Plan:

Maricopa County Board of Supervisors

District 1, Fulton Brock

District 2, Don Stapley

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District 5, Mary Rose Wilcox

Flood Control District of Maricopa County

Mike Ellegood

Tom Johnson

Dick Perreault

Russ Miracle

Doug Williams

Kelli Sertich, Project Manager

Marilyn DeRosa, Project Manager

Amir Motamedi

Theresa Pinto

Dennis Holcomb

City of Peoria

Dave Moody

Debra Stark

Burton Charron

Arizona State Land Department

V. Ottozawa-Chatupron

Cherly Doyle

State of Arizona Game and Fish Department

Tim Wade

Consultants

Scot Schlund, Principal
Stantec Consulting Inc.

Patrick J. Ellison, Project Manager
Stantec Consulting Inc.

Michael C. Gerlach, Project Engineer
Stantec Consulting Inc.

Carol Johnson, Project Planner
Stantec Consulting Inc.

Bob Larkin, Environmental Overview
Stantec Consulting Inc.

Dr. Robert Johnson, Biological Resources
Johnson & Associates, EEI, Inc.

Jon Fuller, Geomorphology
JE Fuller Hydrology and Geomorphology

Leslie Dornfeld, Multi–Use Recreational Potential
DFD Architecture

Mike Eagan, Landscape Architect
DFD Architecture

Laura Patty, Visual Resources
DFD Architecture

Renee Chilton, Public Involvement
RH & Associates

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Introduction

The natural physical character of the North Peoria Area Drainage Master Plan study area is unique to north central Maricopa County, the City of Peoria, and the Phoenix metropolitan area. The area is characterized by diverse landforms, sinuous washes that dissect the terrain, and varied plant communities. The area is also rich in wildlife, and historical and cultural resources. The natural topography and vegetation types associated with topography offer a scenic quality that is unparalleled anywhere else in the valley. The natural physical character also includes flood prone areas and associated ***erosion*** hazards which are public safety concerns.

Twin Buttes

Due to impending development pressures in north Peoria, the Flood Control District of Maricopa County (District) in cooperation with the City of Peoria and under the authority of Arizona Revised Statutes (ARS) Title 48, Chapter 21, initiated the North Peoria Area Drainage Master Plan (North Peoria ADMP). The North Peoria ADMP is a regional approach to watershed management. The District prefers a regional approach to watershed and floodplain management because it enables the District to develop flood control strategies that are both sustainable and sensitive to the environment. This approach works to minimize the public cost of protecting citizens from flooding that may result from private and public development's cumulative effect on drainage characteristics. The North Peoria ADMP provides a uniform and coordinated approach to watershed management. A multi-faceted approach will ensure that present and future residents are protected from the damaging effects of flooding.

The District contracted with Stantec Consulting Inc. (Stantec) to develop the North Peoria ADMP. Stantec assembled a qualified team consisting of hydrologists, engineers, environmental engineers, archeologists, landscape architects, and planners to assist in the development and evaluations of flood control management alternatives. The team worked with District and City of Peoria personnel in the preparation of the ADMP.

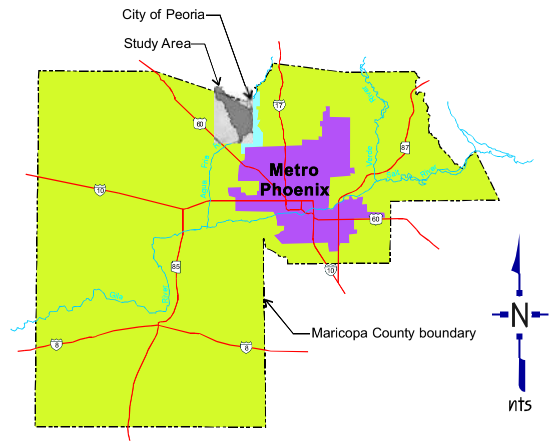
Morgan City Wash

The North Peoria ADMP study area encompasses approximately 73 square miles within unincorporated Maricopa County and the City of Peoria. Numerous watersheds drain the area to the Agua Fria River. Major ***watercourses*** draining to the Agua Fria River are Morgan City Wash, nine unnamed washes, Caterpillar Tank Wash and Twin Buttes Wash. Approximately 66 linear miles of ***watercourses*** are considered in the development of the North Peoria ADMP. The study area does not include the Agua Fria River and associated ***100-year floodplain***. The location of the study area relative to City of Peoria, City of Phoenix, and Maricopa County boundaries is displayed on **Figure 1**.

Development of the North Peoria ADMP includes, public coordination, survey and mapping, **hydraulics**, **hydrology**, **sedimentation** and geomorphic evaluations, environmental and visual resources overviews, identification of flood hazards, identification of **erosion** hazards, historical character evaluation, multi-use recreational opportunities, policies to help guide development and formulation of flood control management alternatives. Detail descriptions of evaluation and overviews are contained in the North Peoria Area Drainage Master Plan, Technical Data Notebook, and attachments to the Technical Data Notebook. The following reports were developed as part of the North Peoria ADMP:

- North Peoria Area Drainage Master Plan, Flood Insurance Technical Data Notebook
- North Peoria Area Drainage Master Plan, Technical Data Notebook
  - *Attachment 1* Filed Survey Report
  - *Attachment 2* Hydrology and Hydraulics
  - *Attachment 3* Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums
  - *Attachment 4* Landscape Character and Visual Assessment Report
  - *Attachment 5* Multi-Use Opportunities Assessment Report
  - *Attachment 6* Plant Communities and Biological Resources
  - *Attachment 7* Historic Character Assessment Report
  - *Attachment 8* Cultural Resources Assessment Report
  - *Attachment 9* Environmental Regulatory Records Review
  - *Attachment 10* Investigation of Existing Ordinances, Policies, Regulations and Standards Affecting Stormwater Drainage
  - *Attachment 11* Floodplain/Erosion Hazard Maps

Figure 1
Vicinity Map



Purpose and Goals

Within the next 25 years, the City of Peoria and Maricopa County north of Beardsley Road to Lake Pleasant will be developed with new homes, shopping, and employment opportunities to serve a population nearing 200,000 people. These residents and businesses will expect protection from natural hazards (such as flooding and **erosion** hazards) that complements the natural environment and scenic beauty of their community. To meet these expectations a comprehensive regional approach to watershed and flood control management is developed. The purpose of the North Peoria ADMP is to identify flooding and drainage patterns and recommend sustainable strategies that will protect the public from flooding and **erosion** hazards. The North Peoria ADMP presents a holistic management approach in that watershed management solutions take into account environmental, landscape, social and economic considerations. Flood control management alternatives are developed to mitigate/

minimize the effect of urbanization on stormwater runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. A holistic approach insures that public's safety and quality of life is maintained. Goals of the North Peoria ADMP are:

- Identify flood and ***erosion*** hazards along major ***watercourses***.
- Develop policies and strategies to protect residents from flood and ***erosion*** hazards.
- Preserve the natural flood control function of the existing washes and ***channels***.
- Incorporate public and private interests, issues, and concerns.
- Minimize future expenditures of public funds for flood control and emergency management.
- Consider environmental and landscape characteristics of the watershed in the development of watershed management alternatives.
- Minimize disturbance of existing floodplain and ***floodway*** ecosystem and habitats.
- Consider multiple-use activities for floodplain areas.

Background

Project Area

The North Peoria ADMP study area encompasses approximately 73 square miles within unincorporated Maricopa County and the City of Peoria. The study area is divided into four planning areas based on physical characteristics and / or geographic location of each planning area. The four planning areas are the Morgan City Area, Big Spring Area, East Terrace Area, and the Twin Buttes Area. The Hieroglyphic Mountains, located within the Morgan City Area, Big Spring Area, and the northern portion of the Twin Buttes Area are characterized by peak, ridge, wash, and valley landforms. Terrain slopes within the Hieroglyphic Mountains range from less than 10 percent to greater than 25 percent. Rock outcrop and rock fragments typify soil constituents within the Hieroglyphic Mountains. Within the Morgan City Area and Big Spring Area, washes are typically incised in rock or well-cemented alluvial material. The East Terrace area located east of the Agua Fria River and the southern portion of the Twin Buttes Area have landforms characterized with terrain slopes of less than 10 percent and are underlain typically by alluvial material. Sinuous natural ***channels*** that are cut into alluvial material characterize washes in the East Terrace Area and in the southern portion of the Twin Buttes Area. With the exception of the lower reach of Morgan City Wash, washes draining the study area watersheds are ephemeral. Springs deliver water to the lower reach of Morgan City Wash providing flow year around. **Figure 2** displays major ***watercourses*** that drain from the study area to the Agua Fria River, specific planning areas delineated by unique physical characteristics, and photographs of some of the physical characteristic of the area.

One of the unique characteristics of the area is the contrast in terrain from the planes and flat lands of the valley to the varied landforms of the Hieroglyphic Mountains. **Figure 3**, Terrain Slope Map, is a graphic representation of terrain slope in the area. Terrain slope is often used by communities and agencies to define significant areas of preservation or areas where special development considerations must be met. Maricopa County encourages preservation of, and applies development considerations for significant mountainous areas with terrain slopes of greater than 15 percent where as the City of Peoria applies special development considerations for areas with terrain slopes of greater than 10 percent.

Land Ownership

There are four primary entities with land ownership in the area: the United States Federal Government, Arizona State Trust Lands, Maricopa County, and private interests. The percent of land owned by each entity is 35% Federal, 32% State Trust, less than 1% County, and 31% private. **Figure 4** displays the distribution of land ownership in the study area.

Land Use

Planning documents developed by communities have a land use element that provides a framework for defining future development patterns. The Land Use element helps guide future growth, revitalization and preservation efforts in the community. An understanding of future or anticipated land use is key to the development of an area drainage master plan. Urbanization of an area typically alters existing rainfall runoff relationships that ultimately could result in flooding impacts to the community.

Currently the study area is predominately undeveloped, however to identify future trends in stormwater runoff and conveyance, the City of Peoria's Land Use Plan developed as part of the city's General Plan is utilized in the development of the North Peoria ADMP. **Figure 5**, Future Conditions Constraints; depicts land use designations, floodplains, and areas of impending development in the study area.

Regional and Local Planning Efforts

There are a number of planning documents that have been developed by county and city agencies to provide direction and guidance in regards to development and future land use within the North Peoria ADMP study area. Planning documents reviewed as part of the data collection are listed in Table 1. A brief summary of the purpose of the document and relevance to the North Peoria ADMP is provided in the following sections.

Table 1
Regional and Local Planning Documents

Agency	Document
City of Peoria	General Plan
	Lake Pleasant / North Peoria Area Plan
	Peoria Desert Lands Conservation Master Plan
	River Master Plan
	Trails Master Plan
Flood Control District of Maricopa County	Agua Fria Watercourse Master Plan
Maricopa County	Comprehensive Plan-Maricopa County Eye To The Future, 2020
	White Tank / Grand Avenue Area Specific Plan
Maricopa County Association of Governments	Desert Spaces
	Desert Spaces-Environmentally Sensitive Development Areas

Peoria General Plan

The Peoria General Plan is the fundamental planning document for the City of Peoria to guide growth and development within the City and its planning areas. The plan was updated to include increased planning efforts mandated by Growing Smarter and Growing Smarter Plus legislative statutes. The General Plan adopted by Peoria's voters went into effect June 15, 2001. Land Use, Recreation and Open Space, Safety, and Environmental Resources elements of the plan provide policy level guidance for development that are directly applicable to the North Peoria ADMP. The General Plan recognizes the unique character and natural resources of the northern half of the city which includes the North Peoria ADMP study area and provides guidance so that there is a balance between facilitating development without endangering the protection of the natural resources in the area.

Lake Pleasant/North Peoria Area Plan

The Lake Pleasant / North Peoria Area Plan, completed by the City of Peoria in November of 1999, provides guidelines to assist in the preservation and enhancement of the environmental, recreational and aesthetic values of the Lake Pleasant Area while allowing for controlled development that is sensitive to the goals of the plan and the natural environment. The Plan recognizes the assets of the unique physical characteristics, flood hazard, biological and visual resources, as well as existing development constraints within the area. The eastern portion of the Morgan City Area lies within the Lake Pleasant / North Peoria Plan boundaries.

Peoria Desert Lands Conservation Master Plan

The major goal of the Peoria Desert Lands Conservation Plan, completed in August of 1999 is to "Maintain the vitality of the unique Sonoran Desert environment by providing high quality passive and active open space areas, while encouraging development that is sustainable and supportive of the environment". To meet the intent of the goal, recommended policies that prescribe a course of action are provided to help guide development. In addition to recommended policies, sensitive land areas identified for potential preservation or conservation are presented. Sensitive land areas referred to as drainage corridors include, Morgan City Wash in the Morgan City Area, Unnamed Washes 1, 2, and 3, and their major tributaries in the Big Spring Area, and Twin Buttes Wash in the Twin Buttes Area.

White Tanks/Grand Avenue Area Plan

Adopted in 1997, the Comprehensive Plan-Maricopa County Eye to the Future 2020, requires that County-area plans be updated to ensure consistency with the Comprehensive Plan. The White Tanks / Grand Avenue Area Plan adopted December 6, 2000 is an update of the White Tank / Agua Fria Policy and Development Guide and the Grand Avenue Corridor Area Land Use Plan. The plan recognizes the scenic beauty in the northern portion of the North Peoria ADMP study area and encourages preservation while recognizing property rights of landowners to develop their property.

Desert Spaces

In 1995, the Maricopa Association of Governments (MAG) adopted the Desert Spaces plan. Desert Spaces is a regional open space management plan designed to guide the members of MAG in protecting open space while allowing for future community growth and development. The intent of the plan is to preserve, protect, and enhance significant natural and cultural resources. Natural resources include upland landforms, rivers and washes, and wildlife habitat. The plan also presents a regional network of trails that when implemented would allow the public to enjoy the diversity of open space that the plan presents. Mountainous areas designated for open space preservation includes the Hieroglyphic Mountains. Approximately half of the North Peoria ADMP study area is located in the Hieroglyphic Mountains.

Desert Spaces-Environmentally Sensitive Development Areas

The Environmentally Sensitive Development Areas (ESDA) Plan adopted by MAG in June of 2000, presents policies and design guidelines for areas identified in the Desert Spaces Plan as "Retention Area". The purpose of the design guidelines is to provide guidance for both the public and private sectors for development projects within Environmentally Sensitive Development Areas. Environmentally Sensitive Areas presented in the Plan include the northern portion of the North Peoria ADMP study area north of the Central Arizona Project Canal.

Environmental Hazards Identification

Within non-urbanized / rural watersheds natural environmental hazards associated with runoff from storm events exist. Without sufficient planning and management, natural hazards are compounded as development occurs within a watershed. In order to protect private and public property, naturally occurring environmental hazards and hazards created by urbanization need to be identified. Environmental hazards associated with storm runoff can be categorized into flood hazards and ***erosion*** hazards. Under the authority of ARS 48-3605, the Arizona Department of Water Resources (ADWR) has established criteria and standards for determining flood and ***erosion*** hazard areas. The North Peoria ADMP considers ***hydrology***, ***hydraulics*** and geomorphic evaluations, sediment engineering and criteria established by ADWR in the identification of flood and ***erosion*** hazards.

Hydrology

Impoundment Area, Upstream of Stock Track

Hydrologic analysis evaluates rainfall-runoff relationships for a given area (watershed) where the volume and rate of runoff is estimated at specific locations. An understanding of the ***hydrology*** of an area, both in existing and future watershed conditions is key in determining flood hazards and in identifying potential impacts to ***watercourses*** draining the watershed due to urbanization. The results of hydrologic analyses conducted as part of the North Peoria ADMP are used for:

- Delineation of ***100-year floodplain*** at selected locations.
- Sedimentation engineering and geomorphic analyses.
- Hydraulic evaluation of flood control management alternatives.
- Hydraulic evaluation of stormwater storage alternatives.

Approximately 126 watersheds were delineated within the study area to determine rainfall runoff relationships for the 2-, 5-, 10-, 25-, 50-, and 100-year frequency storm events for both existing and ***future conditions***. **Figure 6** depicts watersheds evaluated for the North Peoria ADMP.

HYDRAULICS

Big Spring

Hydraulic analyses are conducted to determine the physical characteristics of a ***watercourse*** during a rainfall-runoff event. Hydraulic ***computer models*** facilitate the analysis and are developed to determine extent of flooding, water surface elevations, depth of flow, and velocity of flow for a runoff event. Models are developed for existing natural conditions and to evaluate different flood control management alternatives. Results of models developed to evaluate flood control management alternatives are compared to the results from models that evaluate ***existing conditions*** to assess the impacts of an alternative on a ***watercourse***.

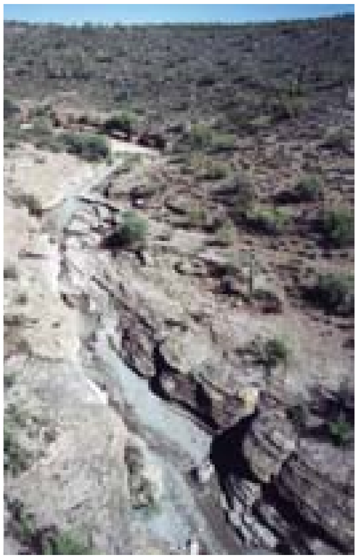
Computer models utilized for the North Peoria ADMP were developed as part of the ADMP or are models from effective Federal Emergency Management Agency (FEMA) ***100-year floodplain*** delineation. Hydraulic models were developed for Unnamed Washes 1, 2, and 3 that drain the Big Spring Area to the Agua Fria River. Existing models developed for the FEMA ***100-year floodplain*** delineation are used as the bases for hydraulic modeling of flood control management alternatives developed for the Twin Buttes Area.

Unnamed Wash 2

Floodplain delineation conducted as part of the North Peoria ADMP were performed utilizing detail and approximate method floodplain ***hydraulics***. Detail ***hydraulics*** requires the development of a computer model that defines ***100-year floodplain*** and ***floodway*** limits. Approximate method hydraulic utilizes an equation referred to as Manning's equation to define ***100-year floodplain*** limits.

Natural Grade Control within Unnamed Wash 2

Geomorphic Evaluation



Unnamed Wash 2 - Canyon Reach

Geomorphology is the study of landforms, the physical processes that forms the land surface and the changes that take place in the evolution of the landform. Geomorphic evaluations conducted for the North Peoria ADMP focused on ***watercourse*** landforms and lateral stability of a ***watercourse***. Geomorphic evaluations conducted are based on field observations, aerial photographs (both historic and recent), historical ***channel*** position, stream longitudinal profile and allowable velocity guidelines. The results of the evaluation documents physical changes to the ***watercourse*** that have occurred over time and suggest the types of changes that can be expected in the future.

In general, historical and field evidence suggests that the floodplains of the ***watercourses*** in the study area, where not incised in bedrock, are subject to lateral ***erosion***. The streams in the study area flow within shallow canyons comprised of Middle to Late Pleistocene alluvium or bedrock. Within recent geologic time, the streams appear to have migrated over the entire canyon bottom, gradually widening the canyons through lateral ***erosion***. The highest ***erosion*** hazards occur on these canyon bottoms and at the margins of the older surfaces that form the canyon walls. The results of the geomorphic evaluation indicate there is a potential for lateral migration in the study ***watercourses*** and thus a potential public safety hazard. Results of the evaluations are used to develop ***erosion*** hazard zones.

Scour Hole, Unnamed Wash 2

Sediment Engineering

The primary objective of the sediment engineering analysis for the North Peoria ADMP is to estimate the existing and future sediment yield, with emphasis on sediment deposition and maintenance requirements upstream of the Central Arizona Project (CAP) canal drainage crossings, and sediment storage for future regional retention / detention facilities.

Sediment yield is the amount of solid material transported past a given point in a stream system, or alternately, the amount of material deposited in an enclosed basin. Sediment yield includes particles small enough to be carried in suspension by the flowing water (suspended load) and particles moved along the bottom of a ***channel*** by rolling, sliding, or bouncing (bed load). When flow velocities are reduced, sediment carried by a stream is deposited. Flow velocities can be reduced by natural or manmade changes in ***channel*** slope or ***channel*** geometry, or by impoundment in flood control basins. Sediment yield is a major concern for public officials in charge of maintaining the effectiveness of flood control structures because ***sedimentation*** behind dams or in ***floodways*** reduces the volume of water that can be stored or transported through the system. A reduction in effective storage volume increases the likelihood of a spillover in larger runoff events, increasing the chances of injuries, damage to the structure itself, property damage downstream and possible loss of human life.

FLOOD AND EROSION HAZARD ZONES

Bank Sloughing within Erosion Hazard Zone

Floodplain delineation and ***erosion*** hazard zones form the basis for the identification of potential public safety hazards associated with natural processes that form the physical characteristics of ***watercourses*** within the study area. Floodplains based on a 100-year peak discharge and ***erosion*** hazards zone delineation were conducted for ***watercourses*** in the Morgan City Area, Big Springs Area, and the Twin Buttes Area, whereas only floodplain delineation was conducted for the East Terrace Area.

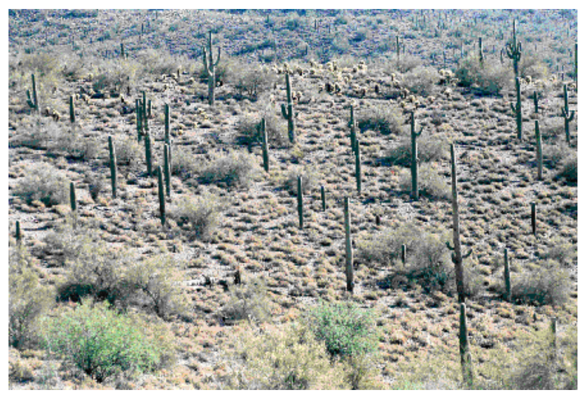
Erosion at Stock Tank Dam

With the exception of the East Terrace Area ***100-year floodplains*** and ***erosion*** hazard zones where delineated for ***watercourses*** with drainage areas of approximately one square mile. In the East Terrace Area, due to soil conditions, rainfall runoff relations were higher than in the rest of the study areas, therefore floodplains were delineated for ***watercourses*** with drainage areas of less than a square mile. Floodplains and ***erosion*** hazard zones developed as part of the North Peoria ADMP, and floodplains previously delineated by other studies are displayed on **Figure 7**, **Figure 8**, **Figure 9**, and **Figure 10**.

ENVIRONMENTAL CHARACTERISTICS

Environmental overviews were conducted to define the ecological / biological resources, cultural / historical resources, regulatory hazardous waste sites, and visual resources of the area. The overviews are based on available existing information and data collected during reconnaissance level field visits. Results of the overviews are then utilized in the formulation and evaluation of flood control management alternatives.

BIOLOGICAL RESOURCE OVERVIEW



Triangle-Leaf Bursage-Foothills Vegetation Community

The focus of the biological resources overview was to describe and map vegetation communities to the association level, identify the potential occurrence of sensitive, threatened, and endangered species and assess sensitive or special status habitats within the project area. Mapping of vegetation communities and assessment of sensitive or special status habitats were based on low intensity field surveys. Threatened, endangered, and sensitive species that potentially occur in the planning area were determined by consulting the species list from the U.S. Fish and Wildlife Service for Maricopa County, and through a search of the heritage database at the Arizona Game and Fish Department.

Twelve plant associations were identified within the project area. Several of the associations have large numbers of plant species in common, such that the associations differ only in respect to the relative proportions of each species. The location and distribution of plant communities are displayed on **Figure 11**.

Morgan City Wash Riparian Gallery Forest

Two special status species, Sonoran Desert tortoise and lowland leopard frog, are known to occur within the planning area. The distribution of lowland leopard frogs is restricted to the lower limits of Morgan City Wash and the Agua Fria River drainage, while Sonoran Desert tortoise probably occur throughout most of the planning area. Additionally, southwestern willow flycatchers and lesser-long nosed bats may not occur within the area at present, but suitable and sufficient habitat exists to support individuals of both species. Additional species might become listed as threatened or endangered by the federal government before development is initiated in the area (e.g., yellow-billed cuckoo). Surveys for species that are currently listed or that may become listed as threatened or endangered, and possibly consultations with the U.S. Fish and Wildlife Service, will be necessary to minimize or avoid development impacts to these species. At present, there are no critical habitat designations for any species within the planning area.

Velvet Mesquite Vegetation Community

The only sensitive and biologically unique habitat within the planning area is the aquatic area and the accompanying riparian gallery forest that occur along the lower reaches of Morgan City Wash. This habitat extends from the confluence with the Agua Fria River upstream to above the springs that deliver water to the wash. The riparian gallery forest is well developed and mature throughout this area. The stream supports numerous species of wetland plants and aquatic species including native fish such as longfin dace (*Agosia chrysogaster*) and lowland leopard frogs.

CULTURAL RESOURCES OVERVIEW

Cultural Resources is a very broad term. For the purposes of the North Peoria ADMP, we refer to cultural resources within the context of preservation. A cultural resource includes prehistoric, historic, architectural, and traditional cultural sites. These sites are considered important, because they represent locations and data that can inform us about cultures and cultural change through time.

Cultural Resource Site

Cultural resource laws are designed to afford protection to significant sites so that important cultural and historical information is not lost. Protection can occur by simply protecting sites, or by professionally excavating them before they are destroyed in order to gather relevant information.

The Cultural Resources Overview is based on a literature review of existing archeological databases. The overview describes the location and significance of known cultural resources. Of the 46,720 acres within the study area approximately 7,703 acres have been previously surveyed. This computes to approximately 17 percent coverage of the project area, with 83 percent of the project area not surveyed. A total of 239 surveys were accomplished within the project area, of which 325 archaeological sites were observed, with 278 of those prehistoric, 35 of those historic, and 12 of those multi-component sites. **Figure 12** displays the location of archeological sites in the project area determined from the overview.

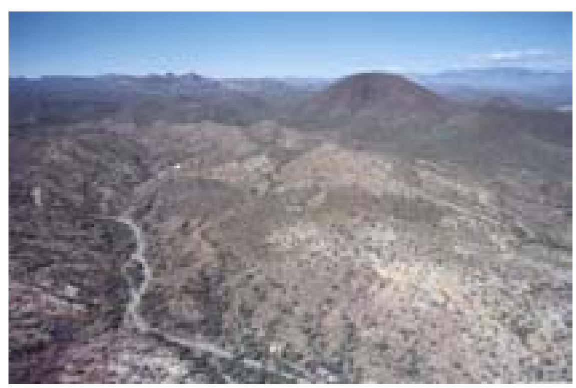
LANDSCAPE CHARACTER AND VISUAL RESOURCES

Landscape Character and Visual Resources Assessment evaluations are conducted as part of the North Peoria ADMP for the purpose to:

Spring Flowers

- Assess the scenic qualities / attractiveness of the existing natural and cultural features.
- Assess the existing visual conditions or scenic integrity.
- Identify existing major viewing points and landmarks with the intent that they be focal points for possible flood control management alternatives.
- Develop landscape character themes (including existing, future, and historic) that could be incorporated into the design of flood control management alternatives.
- To aid in the development of landscape design guidelines that will achieve the desired character theme(s) as they apply to possible flood control management alternatives.

Visual resources are defined by the scenic quality / attractiveness of the natural and cultural features of an area. Loosely defined scenic attractiveness rates the inherent attractiveness of a landscape on a scale of (A) distinctive, common, (B) typical, or (C) indistinctive. Landforms such as mountain peaks and ridges, plains, valleys, and washes are taken into consideration along with the presence of water in defining scenic attractiveness. Criteria published in the Landscape Character Types of the National Forest in Arizona and New Mexico by the USDA Forest Service (1989) were utilized to rate scenic attractiveness. **Figure 13** displays scenic attractiveness classifications for the study area.



Upper Morgan City Wash Watershed

Landscape character units for the study area are defined utilizing criteria per the Landscape Aesthetics Handbook #701 published by the USDA Forest Services (1995). Landscape character is the “particular attributes, qualities and traits of a landscape that give an image and make it identifiable or unique”. In the project area landscape character units are based on tectonic provinces, vegetation types and existing land use. Within the project area six existing landscape character units were identified: Mountain Lands, Slopes, Plains, Commercial Use, Rural Subdivisions, and Riparian Gallery Forest.

Twin Buttes Wash

Multiple-Use Opportunities

Multiple-use opportunities are opportunities identified to meet local community needs for recreation, open space, protection and enhancement of natural landscape and local community character as related to proposed flood control management alternatives. Existing and proposed recreational facilities, management plans and trails plans are inventoried on a regional and local level so that the extent to which flood control management alternatives could be used to enhance and connect these resources can be identified. Regional passive recreational resources (existing and planned) adjacent to the study area include, Lake Pleasant, Hells Canyon Wilderness Area, Castle Hot Springs, and linear park / open space networks (City of Peoria's Rivers Master Plan (January 1999)) that connect with a trail system proposed in the City of Peoria Trails Master Plan along the Agua Fria River. **Figure 14** displays the recreational regional context of the area. Existing local recreational resources are characterized by the privately owned Canyon Raceway, Pleasant Valley Airport, and open space land use proposed in the City of Peoria's General Plan. The City of Peoria's General Plan recommends that the environmentally sensitive areas in the northern region (includes portions of the North Peoria ADMP study area) of the City, additional landscaped retention areas within Planned Area Developments, water recharge areas, open space buffers adjacent to Lake Pleasant Regional Park, the Agua Fria and New River recreation corridors and New River Dam retention area be used to meet its open space goals of providing 10 acres of open space per 1000 population.

As an element of the North Peoria ADMP, an assessment of opportunities and limitations for integrating multiple-use recreational features into preferred flood control management alternatives was conducted. Opportunities identified are primarily located along Morgan City Wash in the Morgan City Area, Unnamed Washes 1, 2 and 3 in the Big Spring Area, and Caterpillar Wash and Twin Buttes Wash in the Twin Buttes Area. The location of multiple–use recreational facilities along these wash corridors are primarily limited to the ***100-year floodplain*** and / or ***erosion*** hazard zone and possible detention / retention facilities, located within a wash, that may be constructed by developers. **Figure 15** displays potential wash corridor trail systems for the north Peoria ADMP area.

Typical Vegetation Along Banks

Public Involvement

An integral part of the preparation of the North Peoria ADMP was public and community participation. Ninety-eight percent of the property in the study area is held by federal, state and private interest with the majority of the private interest (approximately 31% of the area) held by a few individuals or partnerships that are planning on developing their property. Typically, private lands are undeveloped and owners are absentee owners. The nature and distribution of land ownership does not lend itself to a typical public involvement process of conducting a series of public information meetings. A public outreach program consisting of questionnaires, newsletters, individual meetings with landowners and federal, state and local agencies and a public meeting was initiated to obtain public and community participation.

Public Workshop

Landowners in the area were notified of the development, goals, and progress of the plan through individual mailings of newsletters, questionnaires, and public announcements in local newspapers. A public workshop was held to present data collection results, policy development, alternative stormwater management approaches developed for the plan and to obtain comments and suggestions from participants.

Throughout the term of the project, individual meetings were held with engineers and/or planners representing the interests of ongoing development projects. Development projects within the plan area include Lake Pleasant Vistas, Saddleback Heights, White Peaks Ranch, Lake Pleasant Heights, Lakeland Village, Upco, and the groundwater recharge project conducted by the Central Arizona Project.

Flood Control Management Alternatives Development and Evaluation

The North Peoria ADMP provides a regional approach to flood control management. Development of flood control management alternatives and policies that forms the foundation of the plan takes into account engineering, environmental, landscape, social and economic considerations. Watershed management alternatives are developed to mitigate/minimize the effect of urbanization on stormwater runoff and conveyance while recognizing the values of the community and the opportunity to protect the unique characteristics of the region. Flood control management alternatives are evaluated on how well each alternative meets the goals of the North Peoria ADMP. The primary purpose for flood control management alternative development and evaluation is to develop a range of plans that provides public safety from flood and ***erosion*** hazards, determine the cost and benefits of each alternative, qualitatively determine impacts of the alternative on identified environmental resources and to select a preferred management plan.

Flood Control Management Alternatives

Flood control management alternatives developed and evaluated for the North Peoria ADMP are categorized into two groups: ***watercourse*** management. Alternatives and stormwater storage alternatives. Watercourse management alternatives evaluated included a non-structural, a partial structural, a low impact structural, a full structural, and a no action. The full structural alternative is based on current federal, state, and local floodplain management regulations that allow encroachment into the ***floodway fringe***. The full structural alternative typically requires, at a minimum, the structural stabilization of wash side slopes for the entire reach. The partial structural alternative also is based on current floodplain management regulations, however the partial structural solution is applied at only specific locations along the ***watercourse***. The low impact structural alternative allows for development activity to occur within the ***erosion*** hazard zone as long as the activity does not significantly alter the natural form and function of the ***watercourse***. The non-structural alternative defines a corridor that allows the ***watercourse*** to function naturally. The no action (do nothing) alternative provides flood control management based on current federal, state and local floodplain management regulations that allows encroachment into the ***floodway fringe***. Typically, under current regulations encroachments into the ***floodway fringe*** are allowed on a piece-meal fashion without taking into consideration the effect of the encroachment or collective encroachments on the entire ***watercourse***. Typical sections of ***watercourse***-based alternatives are depicted in **Figure 16**, **Figure 17**, **Figure 18**, and **Figure 19**. Stormwater storage alternatives evaluated include the standard practice of retaining the volume of flow from the 100-year, 2-hour event, in-stream, in-line detention alternative and an in-stream, off-line retention alternative. Perspectives of the in-line detention alternative and the off-line retention alternative are presented as **Figure 20** and **Figure 21**.

The evaluation / application of an alternative for a given ***watercourse*** is based on physical and data constraints. Physical constraints include land use, topography, the location, and distribution of rock outcrop, and characteristics of the floodplain (i.e. ***floodway*** limits coincidental with floodplain limits). Data constraints are the availability of hydraulic models. Hydraulic evaluations of ***watercourse***-based alternatives are developed for ***watercourses*** in which detail hydraulic models were developed as part of the study or available from previous studies. The full structural alternative is applied only to ***watercourses*** in the Twin Buttes area below the CAP canal. The partial structural alternative is evaluated for the three unnamed washes that drain the Big Spring Area to the Agua Fria River. The low impact structural alternative is evaluated for all ***watercourses*** in which ***erosion*** hazard zones have been delineated as part of this study. The non-structural alternative and the no action alternative are evaluated for all ***watercourses*** in which hydraulic models were available.

Both Maricopa County and the City of Peoria require retention / detention (stormwater storage facilities) for all new developments. The goal of this requirement is to reduce / minimize the impacts of the increased runoff due to development in the watershed. Ideally, this is accomplished by controlling the post-development runoff such that it is equivalent in magnitude, duration, and temporal distribution to the pre-development conditions. To achieve this goal, both Maricopa County and the City of Peoria use the 100-year, 2-hour storm as the design event for sizing retention / detention facilities.

Traditionally, retention has been accomplished by storing the 100-year, 2-hour runoff volume in below grade basins. These basins typically are drained by percolation into the soil and / or a small outlet structure connected to a ***watercourse*** often via an extensive storm drain system. The effectiveness of this type of facility, both economically and hydraulically, is a function of the soil and terrain characteristics. Shallow soils with low permeability rates and / or soils that occur on steep slopes are not conducive to this particular application.

Fifty percent of the North Peoria ADMP project area have soils types that are characterized by moderate to moderately slow permeability; low to very low available water capacity and shallow depth to bed rock or hard pan, typically less than two feet. Additionally, these soils typically occur on steep slopes. The steep terrain associated with these soils combined with the shallow depth to bedrock results in physical conditions that are not suitable to the traditional technique for providing retention. As a result, the retention / detention requirement for development sites with these characteristics has, in the past, often been waived; however, the presence of such physical characteristics does not mean that alternative methods of retention / detention shouldn't be investigated or required. Therefore, two alternative methods for reducing or decreasing the effects of increased runoff due to development are evaluated for this study area. These methods are in-stream, offline retention and in-stream, in-line detention.

ALTERNATIVE EVALUATION

Flood control management alternatives are evaluated on how well each alternative meets the goals of the North Peoria ADMP. The evaluations of the alternatives are based on weighted elements of four criteria. The criteria are Public Safety, Social Impacts, Environmental Impacts, and Economic Impacts. A weighting factor was developed by the steering committee that represents the "relative importance" of each element in the evaluation process. The weighting factors were measured on a scale of 1 to 10, where a factor of 10 represented highest importance. Weighing factors of 10, 3, 6, and 4 were used for Public Safety, Social Impacts, Environmental Impacts, and Economic Impacts, respectively.

Each criterion is made up of several elements that are individually rated. A rating system is used to measure the effectiveness of each alternative at meeting the elements of each criterion. The rating system ranges from 1 to 5. A value of 1 represents a "very low" rating at meeting the criteria element, a value of 2 represents a "low" rating, a value of 3 represents a "moderate" rating, a value of 4 represents a "high" rating, and a value of 5 represents a "very high" rating. Rated values for each element are averaged to obtain an average value for the criterion. The average rating value is then multiplied by the appropriate weighting factor to obtain a score for the criterion. Scores determined from the four criterion are then added together to obtain an overall score for the alternative.

Public Safety Criterion

The public safety criterion is based on evaluating the threat for loss of human life, possible damage to structures and property and impacts to water quality resulting from implementation of a given alternative. This criterion is an indicator of how well the proposed alternative will succeed in reducing or eliminating life threatening, or potentially life threatening, flood and ***erosion*** related hazards, as well as reducing the potential for flood and ***erosion*** related damage to public and private properties. The evaluation of the public safety criterion is based on the effectiveness of each alternative in satisfying the two elements of the Public Safety Criterion. The two elements are Protect Life and Property and Water Quality.

Protect Life and Property. Historically, society has experienced loss of life and property due to flooding and ***erosion*** that is associated with a stormwater runoff event. This element rates the function of the alternative to keep the public out of harms way during a ***100-year storm*** event while minimizing potential downstream impacts to life, property and structures.

Water Quality. Federal guidelines mandate that communities develop Best Management Practices (BMPs) to promote water quality. This element accounts for the impacts of an alternative on water quality.

Social Criterion

The evaluation of the social impact criterion is based on the effectiveness of each alternative in satisfying the elements of Community Acceptance, Multiple-use Opportunities, and Compatibility with Other Plans.

Community Acceptance. This element accounts for the input received from the public involvement process. There is a nationwide trend towards promoting non-structural approaches and ecosystem preservation, as witnessed by the removal of flood control structures in many parts of the country. Federal agencies such as the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation have, in recent years, significantly changed their focus from hard engineering solutions to include non-structural alternatives, preservation of natural hydrologic functions, and ecosystem restoration. The specific input from the public involvement process was that the preservation of ***watercourses*** and their associated habitat is more important than maximizing developable land by destroying the natural hydrologic processes, which results from encroaching into ***watercourses***.

Multiple-use Opportunities. This element is an indicator of the multiple-use opportunities of an alternative. Examples of such uses included passive and active recreation, trails, and open space. The effectiveness of the criterion is based on the extent of multi-use opportunities that result from implementing a given alternative.

Compatibility with Other Existing Plans. This element is an indicator of the compatibility of a proposed alternative with planning policies cited in other existing planning documents. Planning documents reviewed are, Comprehensive Plan-Maricopa County's Eye to the Future 2020 (1997), and White Tank / Grand Avenue Area Plan (December 6, 2000); MAG's Desert Spaces Plan (1995) and ESDA (June 2000); and the City of Peoria's General Plan (June 2001), Desert Lands Conservation Master Plan (Auusst 1999), Lake Pleasant / North Peoria Area Plan (November 1999) and Trails Master Plan (January 1999).

Environmental Criterion

The evaluation of the Environmental Criterion is based on the effectiveness of each alternative in satisfying the three elements of Environmental Impacts, Visual Resources and Aesthetic Compatibility, and Impacts on Cultural Resources.

Environmental Impacts. This element consists of two sub elements: complexity of environmental permitting and impacts on biological resources. Complexity of Environmental Permitting focuses on the acquisition of the U.S. Army Corps of Engineers 404 Permits and 401 Water Quality Certifications. The alternatives are measured based on the potential for needing a 404 Permit, the level of 404 Permit required (Nationwide vs. Individual), and the level of mitigation necessary to gain federal approval to construct the alternative. To evaluate this element, it is assumed that alternatives with structural features will cause disturbance to the land within the Waters of the United States. The more extensive the structural features, the lower the rating. As an example, constructing a wide, rectangular, concrete ***channel*** would place fill within the Waters of the United States, require an Individual 404 Permit and 401 Water Quality Certification, and require extensive mitigation measures to replace the relatively high-value habitat and vegetation associated with the undisturbed desert riparian wash. Impacts on biological resources accounts for the potential impact on biological resources by the proposed alternatives and how well the proposed management alternative will succeed in preserving or restoring the natural riparian environment found along the study ***watercourses***. The most important indicator of this is the ability of a given alternative to preserve wildlife habitat or minimize disruption to existing habitat.

Visual Resource and Aesthetic Compatibility. This element evaluates the relative degree of contrast between the various components of the alternatives and their setting in the landscape. Visual contrast is based on spatial dominance, visual compatibility, color, line, and form.

Impact on Cultural Resources. This element accounts for the potential impact on cultural resources by a given alternative. It is also an indicator of how well the alternatives will succeed in preserving cultural resources.

Economic Criterion

The evaluation of the economic criterion is based on the effectiveness of each alternative in satisfying two elements: Implementation Cost and Maintenance Cost.

Implementation Cost. This element represents the estimated cost of the proposed alternative to the public, either through increased development costs passed on to future residents of the area who will directly benefit from the improvements (local public) or the costs to the general public. The cost for a structural alternative considers the cost of the structural improvements necessary to implement the proposed alternative (a positive cost), the value of land that is reclaimed from the floodplain / ***erosion*** hazard zone by the structural improvements (a negative cost, i.e., benefit). Added together, these costs represent the total net cost of the alternative. The effectiveness of a given alternative is measured by using the total net cost. The lower the net cost the higher the rating for the Economic Criterion.

Maintenance Cost. This element accounts for the potential maintenance costs associated with the structural components of an alternative. It has been assumed that such costs are proportional to the length of bank protection proposed for a given alternative. The greater the bank protection length, the higher the potential maintenance cost and the lower the rating.

SUMMARY OF EVALUATION RESULTS

Flood control management alternatives were developed for ***watercourses*** in the Morgan City Area, Big Spring Area, and Twin Buttes area. Table 2 lists the ***watercourse*** evaluated within the specific planning areas. The ***watercourses*** within a planning area have similar physical and hydraulic characteristics and therefore are evaluated collectively. Results of the evaluation are applied to all ***watercourses*** in a specific planning area. Scoring results, for ***watercourse*** management alternatives, for planning areas are listed in Table 3.

Stormwater storage flood control management alternatives were developed and evaluated for the Big Spring Area with the intent that the results are applied to other planning areas that have characteristics such that the standard practice of retaining the 100-year, 2-

Table 2
Watercourses Evaluated

Planning Area	*Watercourse*
Morgan City	Morgan City Wash
Big Spring	Unnamed Wash 1
	Unnamed Wash 2
	Unnamed Wash 3
Twin Buttes	Caterpillar Tank Wash
	Twin Buttes Wash
	East Garambullo Wash
	West Garambullo Wash
	White Peak Wash
	West Fork of White Peak Wash

Table 3
Summary of Evaluation Results *Watercourse* Management Alternatives

Planning Area	Evaluation Criteria	Weighting Factor	Non-Structural		Low Impact Structural		Partial Structural		Full Structural		Do Nothing	
			Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Morgan City	Public Safety	10	8	80	8.3	83	NA	NA	NA	NA	6	60
	Social	3	11	33	9.8	29.4	NA	NA	NA	NA	7.5	22.5
	Environmental	6	14	84	10.8	64.8	NA	NA	NNA	NA	5	30
	Economic	4	6	24	6.6	26.4	NA	NA	NA	NA	2	8
	Total Score =			221		203.6						120.5
Big Spring	Public Safety	10	8	80	8.3	83	7.5	75	NA	NA	6	60
	Social	3	10	30	9.8	29.4	9	27	NA	NA	7	21
	Environmental	6	15	90	10.8	64.8	7.8	46.8	NA	NA	5	30
	Economic	4	6	24	6.6	26.4	4.4	17.6	NA	NA	2	8
	Total Score =			224		203.6		166.4				119
Twin Buttes	Public Safety	10	7.9	79	8.3	83	NA	NA	6.7	67	6	60
	Social	3	10.9	32.7	9.8	29.4	NA	NA	7.2	21.6	7	21
	Environmental	6	14.5	87	10.8	64.8	NA	NA	4.6	27.6	5	30
	Economic	4	6	24	6.6	26.4	NA	NA	4	16	2	8
	Total Score =			222.7		203.6				132.2		119

Table 4
Summary of Evaluation Results Stormwater Storage Based Alternatives

Planning Area	Evaluation Criteria	Weighting Factor	In-Stream, Off-Line Retention		In-Stream, In-Line Detention	
			Rating	Score	Rating	Score
1	2	3	4	5	6	7
Big Spring	Public Safety	10	7	68	6	64
	Social	3	11	34	10	31
	Environmental	6	10	60	9	53
	Economic	4	6	24	6	24
Total Score =				186		172

hour event is not practical. Scoring results for the stormwater storage are listed in Table 4.

Preferred Flood Control Management Alternatives

The preferred ***watercourse***-based flood control management alternative is the non-structural alternative. The non-structural alternative defines a corridor that allows the ***watercourse*** to function naturally and is defined by the ***100-year floodplain***, ***erosion*** hazard zone and a buffer if applicable between human activity and a wash corridor. The plan recognizes that there may be situations in which development activities may be required or desired within the ***erosion*** hazard zone, for this situation the plan presents a low impact structural alternative. Channelization is not a preferred flood control management alternative; however, the plan also recognizes that there may be situations in which channelization may be required. The preferred stormwater storage alternative is the standard practice of retaining the volume from the 100-year, 2-hour rainfall event, however this practice may not be practical for certain portions of the study area. The standard retention practices if implemented within an entire watershed would have negative impacts in regards to sustaining native vegetation along ***watercourses***. The plan offers two stormwater reduction alternatives to the standard practice. The stormwater storage alternatives are based on reducing post-development peak discharges to pre-development magnitudes. The alternatives are referred to as the in-stream, off-line retention alternative and in-stream, in-line detention alternative. The in-stream, off-line retention is the preferred alternative of the two.

Compatibility with Other Planning Documents

Components of preferred flood control management alternatives are compared to components of environmental resources, safety, and open space elements of other planning documents to ensure that there is consistency between the intent of the North Peoria ADMP and the intent of other planning documents. Table 5 lists the themes of objectives and policies from the North Peoria ADMP and other applicable planning documents that have similar goals.

Table 5
Summary of Regional and Local Planning Objectives

Planning Document	Objective Policies: Discourage Development within *100-year floodplain in Environmentally Sensitive Areas*	Disrourage Development within *Erosion* Hazard Zones	Encourage the Use of Non-Structural Flood Control Management Techniques Where Applicable	Promote the Design of Flood Control Structures that are Sensitive to the Natural Environment	Manage Increases in Stormwater Runoff due to Urbanization	Changes to Natural Drainage Patterns Should be Avoided in Environmentally Sensitive Land Areas	Appropriate Structures Should be Designed for Roadway Cross Drainage	Recognition / Preservation of Unique Landforms	Designation of Environmentally Sensitive Areas	Recommend Development Guidelines that are Sensitive to the Natural Environment	Preserve and Protect Habitat Areas and Areas of Vegetative Significance	Preserve and Protect Historical and Archaeological Resources	Recognize Multiple-Use Recreational Opportunities within an Open Space Network	Establish Buffer Between Human Activities and Environmentally Sensitive Areas	Recommend that Special Development Guidelines for Area with Terrain Slopes Greater than 10% (City of Peoria) or 15% (Maricopa County).
City of Peoria's General Plan (June 2001)	✠				✠	✠	✠	✠		✠	✠	✠	✠	✠	✠
Lake Pleasant/North Peoria Area Plan (November 1999)	✠	✠	✠	✠				✠	✠	✠	✠	✠	✠	✠	✠
Peoria Desert Lands Convervation Master Plan (August 1999)	✠					✠		✠	✠	✠	✠	✠		✠	✠
Desert Spaces (1995)	✠		✠	✠	✠			✠	✠	✠	✠	✠	✠	✠	✠
White Tank Grand Avenue Area Specific Plan (December 6, 2000)								✠		✠	✠	✠	✠		✠
North Peoria Area Drainage Master Plan (2001)	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠	✠

RULES OF DEVELOPMENT

INTRODUCTION

Communities develop drainage ordinances, policies, and standards with the intent to mitigate / minimize flooding impacts due to urbanization of a watershed. The purpose of these regulations is to minimize the occurrence of losses, hazards, and conditions adversely affecting the public health, safety, and general welfare that might result from flooding caused by the surface runoff of rainfall. Potential rainfall runoff relation impacts to a watershed due to urbanization are:

- Decrease of stormwater infiltration capacity within a watershed due to urbanization increases peak discharge from a watershed unless measures are undertaken to reduce post development peak discharges.

- An increase of peak discharge, frequency, and runoff volume due to urbanization in a watershed increases the potential for ***erosion*** and ***sedimentation*** within ***watercourses***.

- An increase in ***erosion*** potential can result in loss of property and riparian habitat.

- Due to an increase in peak discharge, existing drainage structures downstream of newly urbanized areas will be undersized.

- Increase in peak discharge increases the amount of property within a floodplain. Existing structures within or adjacent to the predevelopment floodplain are at risk of a greater flood impact.

- Disruption of natural flow paths can disrupt the natural system equilibrium and induce bank ***erosion*** and long-term ***degradation*** of the ***channel*** bed.

- An increase in bank ***erosion*** and long-term ***channel*** bed ***degradation*** can result in the need of grade control structures and bank stabilization.

- Increased ***erosion*** and deposition will result in greater costs for future structures, higher potential damage and likelihood of failure of existing structures, and increased maintenance cost.

- Increased deposition results in loss of ***channel*** capacity and increased flood levels.

NORTH PEORIA AREA DRAINAGE MASTER PLAN ELEMENTS

The North Peoria ADMP is one of the many tools that have been developed to guide growth and development in the study area so that impacts of urbanization on the environment are minimized. The focus of the North Peoria ADMP is on flood and ***erosion*** control management; however, the plan takes into consideration the impacts of different flood control management alternatives on environmental, cultural, and visual resources and looks at multi-use opportunities. The intent of this plan is to work in conjunction with other planning documents and ordinances developed by the City of Peoria and Maricopa County. The plan is to be used by policy makers in the City of Peoria and Maricopa County, future residents, and developers when making decisions concerning development in the area.

Implementation of and guidance provided by the plan is based on a set of management goals, objectives, and policies for each of the four elements of the plan. The elements are Environmental Hazard Identification, Development and Planning Considerations, Environmental, and Multiple-Use Opportunities. The following definitions of goal, objective, and policy area are offered as a guide for the users of the plan.

Goal: *A statement that describes in general terms a desired* ***future condition.***

Objective: A statement that describes a specific condition to be attained.

Policy: A course of action or rule of conduct to be used to achieve the goals and objectives of the plan.

The plan area for the North Peoria ADMP lies within two jurisdictional areas, Maricopa County and the City of Peoria. The specific guidance that is offered by each of the governmental bodies within their adopted planning programs vary depending on their needs and their vision for managing growth. The goals objectives and policies developed for the North Peoria ADMP are applicable to both jurisdictions; however, reference is made to other planning documents that offer development guidance. The user of this document should also take into consideration specific goals, objectives and policies developed for the area by both jurisdictions.

North Peoria ADMP elements, goals and accompanying objectives and policies that are similar or the same as guidance/direction provided in adopted planning documents, and/or ordinances are presented or repeated for this plan because they are instrumental to the implementation and maintenance of the preferred flood control management alternatives of the plan.

<u>Environmental Hazards Identification</u>

Within non-urbanized/rural watersheds natural environmental hazards associated with runoff from storm events exist. Without sufficient planning and management, natural hazards are compounded as development occurs within a watershed. In order to protect private and public property and the health and general welfare of the public, naturally occurring environmental hazards and hazards created by development need to be identified. Environmental hazards associated with storm runoff can be categorized into natural flood hazards, ***erosion*** hazards, sediment deposition hazards, and flood hazards associated with development.

The following environmental hazard identification Goals, Objectives, and Policies seek to advance the intent of Federal, State, County, and City of Peoria guidelines for the treatment of identified environmental hazards.

Goal EH1 - Identify environmental hazards associated with stormwater runoff.

Objective EH.1.1

Identify special flood hazard zones per the guidelines of FEMA and the District.

Policy EH.1.1.1

Require all development to use at least the regulatory ***100-year floodplain*** delineation identified by FEMA and/or the District and associated 100-year peak discharges in their planning and design efforts.

Policy EH.1.1.2

Require all development to delineate flood hazards zones for areas not covered by delineation conducted by FEMA or the District.

Objective EH1.2

Identify potential flood hazards associated with existing man-made structures within the planning area. Possible examples of man-made structures include, but are not limited to, stock tanks, drainage crossings at roadways and canals, levees, bridges, and retention basins.

Policy EH1.2.1

Evaluate the structural integrity and possible failure of existing earthen dams along ***watercourses***. (Earthen dams have been identified in the Big Spring, East Terrace, and Twin Buttes planning areas.)

Policy EH1.2.2

Evaluate ponding limits upstream of a ***watercourse*** crossing of roadways and canals.

Objective EH1.3

Identify ***erosion*** hazard zones associated with ***watercourses***.

Policy EH1.3.1

Require all new development to use the ***erosion*** hazard zone identified by the District in their planning and design efforts.

Policy EH1.3.2

Require all new development to delineate ***erosion*** hazard zones for areas not covered by delineation's conducted by the District.

Objective EH1.4

Identify stream reaches that have experienced historical and / or recent long-term ***degradation*** or ***aggradation***.

Policy EH1.4.1

Require all new development to take into account the effect of ***aggradation*** and ***degradation*** on drainage facilities (such as retention / detention, off-line / in-line facilities). Drainage facilities constructed in the ***watercourse*** shall strive to maintain the ***watercourse*** sediment continuity.

Development/Planning Considerations

The following Development / Planning Goal, Objectives, and Policies provide guidance to minimize potential impacts to a watershed due to development.

Goal DP1 - Establish area-specific Design and Planning Standards to promote development that acknowledges environmental hazards associated with stormwater runoff, preserves the natural integrity and function of ***watercourses*** *within a watershed and minimizes the potential to increase the magnitude of the hazards due to urbanization.*

Objective DP1.1

Discourage development in ***100-year floodplain*** and associated ***erosion*** hazard setbacks.

Policy DP1.1.1

Encourage non-structural flood control techniques over typical structural flood control techniques.

Policy DP1.1.2

Where structural control measures are deemed necessary, encourage the use of low impact structural flood control techniques. Low impact structural measures shall not adversely affect the stability of a ***watercourse*** or adversely alter flooding and ***erosion*** conditions on adjacent property. Low impact structural alternatives shall complement the visual integrity of the area.

Policy DP1.1.3

Development in, or modification of, the floodplain is discouraged. Should there be a need to modify the floodplain, the modifications shall result in minimum disruption of the natural sediment transport capacity of the ***channel*** and floodplain.

Objective DP1.2

Encourage design and planning efforts that mitigate potential disruptions to the predevelopment function of a watershed due to development.

Policy DP1.2.1

Discourage changes to natural drainage patterns in rural and low-density residential land use areas.

Policy DP1.2.2

In areas where the non-structural alternative is applied, preserve vegetation on and adjacent to the ***channel*** banks, and in the floodplain in order to maintain the stability of existing ***channel*** banks and minimize the potential for lateral ***channel*** movement.

Policy DP1.2.3

Design roadway alignments in such a manner that runoff collected by the roadway is conveyed to its historic ***watercourse***.

Policy DP1.2.4

Design roadway ***watercourse*** crossings such that the alignment of the roadway is perpendicular to the ***watercourse*** alignment and at locations where the floodplain and ***erosion*** hazard limits are narrow.

Policy DP1.2.5

Discourage roadway crossing of ***watercourses*** at locations where the ***watercourse*** is ***braided***.

Policy DP1.2.6

Provide access roads to culvert or bridge roadway crossing of ***watercourses*** to facilitate access by maintenance vehicles.

Policy DP1.2.7

Culvert/bridge crossings shall minimize disruption to the natural ***channel*** form and function.

Policy DP1.2.8

Design culvert crossings to account for potential clogging due to the accumulation of ***sediment*** and debris.

Policy DP1.2.9

Design drainage crossings to minimize downstream ***scour***, minimize the risk of ***erosion*** of roadway approaches, and maintain sediment continuity up to the bank full discharge.

Policy DP1.2.10

At-grade roadway crossings of ***watercourses*** should only be considered for ***watercourses*** that are characterized by shallow flow conditions. At-grade roadway crossings in rural and low-density residential land use areas are acceptable (specific design criteria such as allowable depth of flow over the roadway will need to be met) with agency approval.

Policy DP1.2.11

The standard practice for retaining the volume of runoff from the 100-year, 2-hour storm event should be employed unless it is demonstrated not to be practicable. The standard retention practice is encouraged for commercial, business park/industrial and high-density residential land use areas. An acceptable alternative to the standard practice is a facility that reduces post-development peak discharges to pre-development magnitudes.

Policy DP1.2.12

Encourage the use of in-stream, in-line detention or in-stream, off-line retention where it can be demonstrated through engineering analyses that infiltration rates, and/or topography does not merit incorporating stormwater retention facilities, and where reducing post-development peak discharges and runoff volumes to pre-development conditions can be achieved. These stormwater storage facilities inherently to not have water quality benefits for managing pollutants in stormwater. Stormwater quality best management practices will need to be employed in the watershed within or upstream of the receiving facility. Typically, the first flush from a runoff event will need to be retained and treated.

Policy DP1.2.13

Prohibit use of irrigation canals as an outfall for stormwater runoff.

<u>Environment</u>

The project area for North Peoria ADMP offers a unique biological resource, aesthetic character, and is rich in natural and cultural resources. The plan offers guidelines for future development in a comprehensive manner that strives to identify and integrate environmental features such as the existing biology, visual resources, watersheds and drainage patterns and cultural resources for the purpose of watershed and ***watercourse*** management.

Biological Resources

Goal BR1 - Preserve sensitive habitats within the North Peoria ADMP Peoria project area.

Objective BR1.1

The reach of ***perennial flow*** for Morgan City Wash and Agua Fria River and the adjacent riparian habitats should be protected from future development in order to maintain the ecological integrity and intact condition of these habitats.

Policy BR1.1.1

Encourage that developers contact the Arizona Game and Fish Department for specific development design considerations for areas adjacent to the ***perennial flow*** reach for Morgan City Wash and the Agua Fria River located in the Morgan City Area.

Objective BR1.2

Riparian vegetation habitats should be preserved along major washes in the Morgan City, Big Spring, East Terrace, and Twin Buttes areas to enhance bank stability, to decrease lateral ***erosion***, and to maintain the existing sediment balance of streams.

Policy BR1.2.1

Recommend that vegetation and an adjacent buffer zone be preserved along major washes.

Other applicable policies and guidelines for preservation of sensitive habitats, buffer areas adjacent to riparianriparian corridors, preservation of significant stands of representative plant communities and revegetation of disturbed areas are presented in the Comprehensive Plan-Maricopa County Eye to the Future 2020 (1997), and the ESDA (June 2000) for areas within Maricopa County. For areas within the City of Peoria, applicable policies and guidelines are presented in the City of Peoria's General Plan (June 2001), Peoria Desert Lands Conservation Master Plan (August 1999), and the Lake Pleasant / North Peoria Area Plan (November 1999).

Visual Character

Goal VC1 - Maintain the existing visual character (natural, historic) of the region.

Objective VC1.1

Minimize the visual impact of stormwater storage facilities.

Policy VC1.4.1

Encourage that stormwater storage facilities be designed to appear in conformance with the natural contours and alignment of the terrain.

Objective VC1.2

Encourage maintenance of the natural wash side-slope texture and color in areas of disturbance.

Policy VC1.2.1

Where constructed, flood control facilities and side-slope stabilization measures should match the adjacent terrain in color and texture.

Objective VC1.3

Minimize the number of wash crossings in order to prevent disrupting views up or down the wash. Minimize impacts to plant and animal habitats, and avoid disturbing the existing sediment balance, decrease the need for public maintenance and minimize ***scour*** and deposition.

Policy VC1.3.1

Where utility, trails, or roadway crossings are necessary, cross perpendicular to wash, at the narrowest point and / or at the point of least vegetation disturbance.

Policy VC1.3.2

Replant disturbed areas using existing native plant species types and densities that are consistent with ***existing conditions***.

Other applicable policies and guidelines for preservation of landform visual resources are presented in the Comprehensive Plan-Maricopa County Eye to the Future 2020 (1997), Maricopa County's Zoning Ordinance (Hillside Development Standards (August 1993)) and the ESDA (June 2000) for areas within Maricopa County. For areas within the City of Peoria, applicable policies and guidelines are presented in the City of Peoria's General Plan (June 2001), Peoria Desert Lands Conservation Master Plan (August 1999), Lake Pleasant / North Peoria Area Plan (November 1999), Zoning Ordinance (September 1995 (Hillside Development Overlay District)).

Cultural Resources

Our cultural resources inform us of prehistoric and historic cultures and cultural change through time. Both Maricopa County and the City of Peoria recognize the importance of cultural resources and have adopted conservation and preservation policies that strive to protect our cultural resources. Applicable policies and guidelines for the identification, protection and conservation of cultural resources are presented in the City of Peoria's General Plan (June 2001), Comprehensive Plan-Maricopa County Eye to the Future 2020 (1997), and Maricopa County's Desert Spaces Plan (1995).

Multiple-Use Opportunities

As an element of the North Peoria ADMP, an assessment of opportunities and limitations for integrating multiple-use recreational features into preferred flood control management alternatives was conducted.

Opportunities identified are primarily located along Morgan City Wash in the Morgan City Area, Unnamed Washes 1, 2, and 3 in the Big Spring Area, and Caterpillar Wash and Twin Buttes Wash in the Twin Buttes Area. The location of multiple–use recreational facilities (identified as part of this study) along these wash corridors are primarily limited to the ***100-year floodplain*** and / or ***erosion*** hazard zone and possible detention / retention facilities, located within a wash, that may be constructed by developers. Multiple-use opportunities constraints are the physical dimensions of the ***100-year floodplain*** and ***erosion*** hazard zone and steep terrain. Wash corridors in the Morgan City Wash Area, Big Spring Area, and the Twin Buttes Area above the CAP canal are typified by incised ***channels***, steep banks, narrow ***floodway*** limits that are coincidental with floodplain limits (minimum development potential with floodplain) and ***erosion*** hazard zones that are not significantly different than the ***100-year floodplain*** limits. Twin Buttes below the CAP Canal is characterized by a wider floodplain and ***erosion*** hazard zone than the reach above the CAP. Given the ***100-year floodplain*** and ***erosion*** hazard zone dimensions and steep terrain constraints multiple-use opportunities associated with flood control management alternatives are primarily limited to trails and open space located within a wash corridor (the wider the floodplain / ***erosion*** hazard zone the greater the opportunity). Multiple-Use opportunities could be enhanced by planning recreational facilities located outside of the wash corridor that connect to potential trail systems / open space areas within and adjacent to a ***watercourse***.

Planning efforts for multiple-use recreational facilities in the North Peoria ADMP shall include where merited the incorporation of guidelines and standards developed for the City of Peoria and Maricopa County in various planning documents that include, the City of Peoria's Trails Master Plan (January 1999) and River Master Plan (January 1999), the Flood Control Districts Agua Fria Watercourse Master Plan (2001), Maricopa County's, Highway 74 Scenic Corridor Overlay Zoning Ordinance XXII-F-1, (August 1993) and, Maricopa County's Parks and Recreation Department, Proposed Maricopa County Regional Trail System (on going).

The following general goals are offered as opportunities to meet local community needs for recreation and open space. Specific objectives and policies are not developed as part of the North Peoria ADMP. Users of the North Peoria ADMP should consult with the appropriate jurisdiction concerning specific planning elements, design criteria, and standards for multiple-use recreational needs. Discussion concerning opportunities and constraints for multiple-use recreation, identified as part of the North Peoria ADMP, is located in North Peoria ADMP, Technical Data Notebook, Attachment 5, Multi-Use Opportunities Assessment Report.

Goal RR1 - Promote continuous trails and vistas of scenic areas along accessible washes.

Goal RR2 - Promote connectivity between possible wash corridor trail systems and to development, area destinations, and other shared-use recreational facilities.

Goal RR3 - Protect the integrity of washes while providing opportunities for recreation and the enjoyment of the natural environment and scenic areas.

DESIGN GUIDELINES

The following design / planning guidelines are presented to aid designers and planners in their efforts. The guidelines are in part from and in addition to guidelines and criteria presented in Maricopa County Drainage Design Manual Volume II-Hydraulics, State Standards developed by the Arizona Department of Water Resources and the City of Peoria Infrastructure Development Guidelines.

Unnamed Wash 2

Flood Hazards

According to ARS 48-3609A and under the authority outlined in ARS 48-3605A floodplain delineations shall be conducted on all ***watercourses*** with drainage areas more than ¼ of a square mile or having a 100-year estimated flow rate of more than 500 cfs. Floodplain delineations shall be conducted in conformance with State Standard 2-96 guidelines, guidelines presented in Maricopa County Drainage Design Manual Volume II-Hydraulics and guidelines presented in the City of Peoria Infrastructure Development Guidelines.

Erosion Hazards

Example of a Structural Bank Protection Measure-Designed to Minimize Lateral Channel Migration

In addition to establishing ***100-year floodplain*** limits, ***erosion*** hazard zone delineations shall be conducted on all ***watercourses*** with drainage areas more than ¼ of a square mile or have a 100-year estimated flow rate of more than 500 cfs. Erosion hazard delineation shall be conducted at a minimum in conformance with State Standard for Watercourse System Sedimentation Balance (State Standard 5-96) guidelines. Depending on the level of detail needed, State Standard 5-96 presents three levels of evaluation. Level I evaluation assumes that the results of the evaluation will be more conservative than results from a Level II or III evaluation. This assumption may be generally true, but may not be valid in areas of potential ***channel avulsion*** or lateral migration. Level II and Level III evaluations are technically more rigorous and the results may or may not indicate reduced ***erosion*** hazard zones relative to the results of a Level I evaluation. Caution should be used in interpreting and applying the results of a Level I evaluation. ***Water-courses*** characterized with wide geologic floodplains, multiple or ***braided channels***, highly erosive banks, poorly vegetated banks, and potential for ***channel avulsions*** should be evaluated at a higher level than Level I.

Areas located within the recommended ***erosion*** hazard zones developed as part of the North Peoria ADMP may be subject to increased risks to public safety that warrant specific development restrictions. Given the level of detail used to develop the recommended ***erosion*** hazard zones the developer / landowner is given the option of completing a more detailed ***erosion*** hazard zone evaluation. A typical scope of work for such an analysis is listed below:

Example of Under-Designed Structural Bank Protection

Typical Scope of Work for Detailed Erosion Hazard Analysis

Channel stability, or the potential for lateral migration, will be evaluated using the following types of analyses:

- Interpretation of Geologic Surfaces
- Historical Analyses
- Field Analyses
- Geomorphic Analyses
- Hydraulic and Empirical Analyses
- Sediment Transport Modeling
- Sediment Yield Analysis
- Sediment Gradation Analysis

Specific tasks likely to be conducted with each of these analyses are outlined below.

Technical Analysis Work Plan

Task 1 – Hydraulics Analysis

Hydraulic Data – HEC-RAS Models. Hydraulic data will be obtained from modeling prepared for the effective FEMA Flood Insurance Studies or new modeling prepared for this study. Specific tasks include the following:

- *Convert HEC-2 to HEC-RAS Format.* In addition to simple translation of the file format from line-based HEC-2 input to window-based HEC-RAS input, the input files will be screened for consistent ***channel*** bank stationing, extraneous GR points, and ineffective flow areas.

- *Plot Cross Sections.* Cross section plots showing existing condition 2-, 10-, and 100-year water surface elevations will be prepared. If the ***future conditions*** flow rates change significantly from ***existing condition*** flow rates, then water surface elevations and ***channel*** geometry will also be plotted for ***future conditions***. Ineffective flow areas in cross sections will also be documented.

- *Prepare Plots of Hydraulic Data from HEC-RAS.* Plots of top width, hydraulic depth, flow cross section area, maximum flow depth, mean ***channel*** velocity, and other data, as needed, will be prepared. At minimum, data from the 100-year event will be plotted. Additional plots for the 10-year event may be made to estimate conditions for the dominant discharge.

- *Define* Channel *Subreaches.* Plots of HEC-RAS data will be used to define characteristic hydraulic reaches based on uniform flow sections, ***erosion*** prone sections (narrow width, high velocity), choke sections (short, constricted reaches), backwater sections upstream of choke sections, longitudinal profile, and potential grade controls. To eliminate potential data scatter between cross sections that may mask trends, running averages of hydraulic data will also be examined to help define reaches. Reach definition will be coordinated with results of geomorphic analyses described below.

Sediment Gradations. Sediment data for the ***channel*** bed and banks will be collected for use in hydraulic and geomorphic analyses. Specific tasks include the following:

- *Sediment Sampling.* Samples of bed sediments from representative locations at approximately one-mile increments throughout the study reach will be obtained for sieve analysis. In addition, surficial sediment size data will be estimated using pebble counts. Bank sediment data will be collected from detailed descriptions and photographic records. These supplemental bed and bank sediment data will be collected at cross sections spaced approximately 1,000 feet apart throughout the study reach. All sampling locations will be noted on a detailed exhibit.

- *Sediment Analysis.* Sediment gradations showing D90, D84.1, D50, D15.9, and D10 will be prepared for each sediment sample. Sediment gradations will be reviewed to verify that reach definitions are supported, and to quantify reach-averaged sediment gradation data. Bed, bank, and overbank sediment characteristics will be compared and quantified. Armored reaches will be identified. Size gradation for HEC-6 model input will be quantified for each subreach. Ranges of size gradation will be defined so that various scenarios of sediment transport analyses can be constructed to identify zones of potential ***aggradation*** or ***degradation***, for use in sensitivity analyses of HEC-6 modeling.

Sediment Yield. Sediment supply to the study reach will be evaluated to quantify sediment sources outside the study limits. Specific tasks include the following:

- *Regional Sediment Yield Estimates.* Sediment yield information will be compiled and analyzed from published reports, regional data, and site specific analysis. Regionalized estimates of sediment yield will be made for the 2-, 10-, and 100-year events. Rough estimates of sediment yield will made using pre- and post-development conditions.

- *HEC-6 Modeling.* Sediment yield estimates will be used as HEC-6 inflow boundary conditions, and will also be used to assess long-term impacts due to sediment accumulations in ponding areas or other backwater areas.

HEC-6 Modeling. HEC-6 models of ***existing*** and ***future*** (alternative) ***conditions*** will be prepared to estimate trends in ***scour*** and deposition in the study reach. The primary goal of the HEC-6 modeling is single event simulation of general ***sedimentation*** trends of ***aggradation*** or ***degradation***, as reflected in a net sediment deficit or surplus. The HEC-6 model will be used to assess sediment transport and related ***channel*** stability for the 10-year, dominant ***channel*** forming discharge, 100-year flood discharge, and possibly an extreme catastrophic discharge event. Specific tasks include the following:

- *Base Condition Modeling.* HEC-6 models for ***existing conditions*** will be prepared, defined as the conditions indicated by the District's topographic mapping.

- *Alternatives Modeling.* Base condition HEC-6 models will be modified, as appropriate, as alternatives are evaluated and as ***floodplain encroachment*** alternatives are considered.

Model development will be based on hydraulic geometry, with appropriate adjustments, from the HEC-RAS models, sediment yield estimates, and size gradations as previously discussed, and on the in-flow hydrographs. Initial model development and verification will be prepared for a test reach. Upon satisfactory verification of the proposed modeling technique, HEC-6 models will be developed in a similar manner for the other study reaches.

Task 2 – Lateral Stability Assessment

Interpretation of Geologic Surfaces. Geologic data will be used to identify and map recent geomorphic surfaces near the stream. The age and position of these surfaces will be used to constrain the rate of lateral and vertical movement over recent geologic time. Specific tasks include the following:

- Interpret aerial photographs.
- Select soil test pit locations.
- Describe soil profiles in soil test pits.
- Describe surficial soil characteristics.
- Inspect surfaces in field.
- Prepare geomorphic mapping.

Historical Analyses. Historical data will be used to identify historical patterns of ***channel*** behavior, historical impacts on the stream by humans, and past rates of lateral and vertical ***channel*** change. Historical data will be used to set the context for interpretation of ***existing conditions*** and prediction of future ***channel*** response. Specific tasks include the following:

- Collect historical maps and topography.
- Collect historical aerial and ground photographs.
- Digitize historical ***channel*** position.
- Determine rates and types of ***channel*** change from digitized ***channel*** plots.
- Measure historical ***channel*** characteristics (width, sinuosity, etc.).
- Plot and compare historical longitudinal profiles.
- Catalogue types of human impacts, plot locations.
- Prepare time line of watershed and ***channel*** changes.

Field Analyses. Field data will be collected to identify areas of ***channel*** instability, quantify ***channel*** and bank characteristics, and document existing ***channel*** conditions. Specific tasks include the following:

- Select index cross section spacing and locations.
- Measure ***channel*** characteristics at index cross sections.
- Measure bank characteristics at index cross sections.
- Document ***existing conditions*** with photographs and notes.
- Perform boulder counts for ***channel*** bed sediments.
- Describe soil pits excavated in the ***channel*** bottom.
- Collect sediment samples from the ***channel*** bottom for sieve analysis.

Geomorphic Analysis. A geomorphic description of the stream characteristics will be prepared to identify appropriate types of hydraulic and empirical analyses, identify existing ***channel*** processes, and to predict trends in future ***channel*** behavior. Specific tasks include the following:

- Describe regional geologic history.

- Collect hydrologic data - peak discharge rates, flow duration curve, mean and monthly flow rates, annual flood series, flood history, climatic data, etc.

- Measure ***channel*** planform characteristics – ***channel*** pattern, meander features, pool and riffle spacing, width, slope, periodicity of narrow and wide reaches.

- Identify evidence of ***paleofloods***.

- Identify stream analogs on adjacent watersheds.

- Evaluate tributary characteristics – drainage area, slope, sediment type, sediment yield, flow rates, location of confluence.

- Assess impacts of tributaries and tributary sediment load on main ***channel*** morphology.

- Apply applicable methodologies from *the District Piedmont Flood Hazard Assessment Manual* (Draft, August 1998) to identify surface ages and stability.

- Perform stream classification.

- Define stream reaches.

Hydraulic and Empirical Analyses. Engineering analyses based on hydraulic data obtained from a HEC-RAS model of the study reach will be performed to assess the potential for bank ***erosion*** and ***scour***. These analyses will be used to determine whether a stream is stable, whether it is likely to experience bank ***erosion*** and / or ***scour***, and what amount of lateral ***erosion*** is likely to occur. Where hydraulic data are required, the computations will be based on 2-, 10-, and 100-year reach-averaged hydraulic data. Specific tasks include the following:

- Revision of HEC-RAS model as described above.

- Define stream reaches using hydraulic data and physical stream characteristics.

- Determine reach-averaged hydraulic data.

- Compute allowable velocity.

- Compute ***scour*** depths (general, local, and long-term).

- Compute armoring potential & depth to armor.

- Compute equilibrium slope.

- Compute reach sediment continuity relationships.

- Apply lane relation to stream reaches.

- Apply regime equations to stream reaches.

- Apply hydraulic geometry relationships to stream reaches.

- Apply empirical ***channel*** geometry relationships to stream reaches.

- Apply appropriate regional lateral stability prediction methodologies – these may include the AMAFCA Prudent Line, ADWR State Standard 5-96, King County (WA) methodology, Rosgen bank assessment techniques, etc.

Impacts Analysis. The proposed development will be modeled to assess the potential downstream and upstream impacts, using the same procedures and methodologies listed above.

Final Product

The final product for these tasks will include a map showing the recommended ***erosion*** hazard zone boundaries and a final report. The final report will include the following:

- Discussion of assumptions and limitations of methodologies.

- Discussion of how the results of the various analyses were combined with the sediment transport modeling results, sand and gravel mining impact assessment analysis, and were translated into the ***erosion*** hazard zone(s).

- Recommendation for future updates of hazard zone boundaries.

- Recommendation for long-term monitoring.

- Recommendations for how to modify the ***erosion*** hazard boundaries and / or under what conditions development can occur within the boundaries.

Earthen Dams (Stock Tanks)

There are a number of stock tanks in the North Peoria ADMP study area. Stock tanks typically consist of a non-engineered earthen dam of varying height placed across a ***watercourse*** to impound stormwater runoff. Vegetation typically lines the impoundment area. Should downstream areas become urbanized these earthen dams would present a hazard. The ADWR Dam Safety Section, has legal jurisdiction over dams (embankments) which exceed certain height and storage limits. ADWR defines a jurisdictional dam as “either 25 feet or more in height or stores more than 50 acre-feet. If it is less than six feet in height regardless of the storage capacity or does not store more than 15-acre-feet regardless of height, it is not jurisdictional”. However even though a structure may not be considered jurisdictional all dams (embankments) in an urban environment are considered as having high hazard potential.

The structural integrity and safety of existing stock tanks shall be evaluated to access downstream impacts to existing or proposed development due to a dam break. Criteria for the design and evaluation of dams can be found in the book entitled “Design of Small Dams”, third edition (1987, Bureau of Reclamation). A professional engineer registered under the laws of Arizona, and having proficiency in civil engineering as related to dam technology, shall conduct evaluation and / or design of an earthen structure.

Retention/Detention Facilities

All detention / retention facilities incorporated within new developments will be designed to retain the peak flow and volume of runoff from the 100-year, 2-hour duration storm event. In the special case when a detention only facility is allowed, the requirement to retain the 100-year 2-hour runoff volume may be waived; however, the post-development peak discharge leaving the site can not exceed predevelopment conditions. In addition to the 100-year event, the effects of more frequent events (2- and 10- year events) of using a detention only facility must be determined.

Standard Retention Practice

Guidelines for the standard practice of retaining the volume of runoff from the 100-year, 2-hour event can be found in “Drainage Regulations for Maricopa County, Maricopa County Drainage Design Manual Volume II-Hydraulics and City of Peoria Infrastructure Development Guidelines.

In-stream, In-Line Detention Basins

In-stream, in-line detention basins are stormwater peak reduction facilities, which could be employed with authorization, from the reviewing agency, instead of the standard practices of retaining the volume of runoff from the 100-year, 2-hour event. The detention facility is typically located in a ***watercourse*** and functions only to reduce post development peak discharges. The facility typically consists of an encroachment into the ***100-year floodplain*** (possibly at a roadway crossing), an outlet structure sized to convey runoff from frequent events such that the natural form and function of the ***watercourse*** is not disturbed (sediment transport capabilities are maintained), and to impound runoff sufficiently, so that there enough storage provided to reduce peak discharges. The following guidelines / consideration should be addressed in the design of such a facility:

- *Basin Outlet (Culvert).* The basin outlet structure should be sized to convey the 100-year existing (pre-development) condition peak discharge without disrupting the sediment transport capabilities of the ***channel*** for the 2-year and 10-year events. If the basin is to be located at a roadway crossing (collector and arterial roadways), then at a minimum, the 100-year future (post-development) condition water surface elevation must not be more than 0.5 feet above the minimum roadway elevation and flow from the 50-year future condition event must not overflow the roadway. Other design guidelines for culverts such as sediment deposition, ***scour*** holes and long-term ***degradation*** must also be considered and these guidelines are presented in subsequent sections.

- *Basin Volume.* The storage volume that is required to satisfy the discharge requirements stated above must consider the potential loss of storage due to sediment deposition. Sediment deposition could potentially impact the hydraulic operation of the basin ultimately effecting the maximum water surface elevation. The storage volume must also be checked in conjunction with the embankment height in regard to the jurisdictional classification. Structures that meet jurisdictional dam classification requirements must be designed in conformance with ADWR requirements, and the design must be approved by ADWR. Jurisdictional classification is discussed previously in the earthen dam guideline section.

- *Drain Time.* The basin must be drained within 36 hours after the end of the design storm.

- *Downstream Impacts.* Hydrologic modeling shall be done to determine if the detainment of runoff or the increased runoff due to development worsens ***existing conditions***. Modeling of multiple storm frequencies (at a minimum 2-, 10-, and 100-year events) may be required.

In-stream, in-line detention basins should not be considered for areas that are characterized by wide flood plains, significant conveyance in the overbank area or multiple ***channels***.

The opportunity to enhance stormwater quality is minimal for an in-stream, in-line detention basin and is not recommended for watersheds in which the land use is high density or because of the land use, the percent of impervious cover is greatly increased unless, stormwater quality concerns have been addressed within the watershed draining to the site.

In-stream, Off-line Retention Basin

In-stream, off-line retention basins are stormwater storage basins that could be employed, with authorization from the reviewing agency, instead of the standard retention practice. In-stream, off-line retention basins function to reduce post development peak discharge and volume to pre-development values. Major elements of the facility are channelization and grade control structures to control the ***hydraulics*** of the flow; inlet works (typically a weir) to direct flow to the basin, low level outlet to drain the basin and a basin of sufficient volume to reduce peak discharges. The following guidelines/consideration should be addressed in the design of such a facility:

- *Modeling Software.* The current recommended modeling software is the Corps of Engineers HEC-RAS v3.0 using the unsteady flow module.

- *Flow Regime.* The flow regime in the ***watercourse*** at the lateral weir structure should be subcritical. This may require the channelization and/or construction of grade control structures. Design guidelines for channelization must also be considered and those guidelines are presented in following sections.

- *Grade Control Structures.* Grade control structures or drop structures may be required to control flow in the natural ***channel*** to subcritical flow conditions.

The armored length of the structure should be sufficient to eliminate development of a ***scour*** hole downstream of the structure.

- *Lateral Weir.* The lateral weir must be sized such that the remaining peak flow and total runoff volume is equivalent to ***existing conditions*** for the design storm. The weir crest elevation must be sufficiently high enough to eliminate potential backwater conditions caused by the ponded water in the basin that would reduce the efficiency of the weir. The potential for ***scour*** at the downstream toe of the weir must be addressed. Sediment deposition within the ***channel*** at the toe of the weir could significantly alter the hydraulic operation of the weir and thus the basin. Sediment deposition at the toe of the weir must be regularly removed.

- *Drain Time.* The basin must be drained within 36 hours after the end of the design storm. To accomplish this, it may be necessary to provide a small bleed-off culvert. For this situation, the minimum practical culvert size should be used. Design guidelines for culverts must also be considered and those guidelines are presented in subsequent sections.

- *Basin Volume.* The storage volume that is required must consider the potential loss of storage due to sediment deposition. Sediment deposition could potentially impact the hydraulic operation of the basin ultimately effecting the maximum water surface elevation. The storage volume must also be checked in conjunction with the embankment height in regard to the jurisdictional classification. Structures that meet jurisdictional dam classification requirements must be designed in conformance with ADWR requirements, and the design must be approved by ADWR. Jurisdictional classification is discussed previously in the earthen dam guideline section.

- *Downstream Impacts.* Hydrologic modeling shall be done to determine if the detainment of runoff or the increased runoff due to development worsens ***existing conditions***. Modeling of multiple storm frequencies may be required.

- *An in-stream, off-line retention basin* reduces peak discharge in a ***watercourse*** by capturing flow near the peak of the hydrograph and therefore offers minimal opportunities for enhancement of stormwater quality. Stormwater quality enhancement deals with managing flow at the beginning of the ascending limb of a hydrograph. Stormwater quality concerns and best management practices shall be addressed/employed upstream of the facility.

Floodplain Encroachment

For most reaches of the major ***watercourses*** in the North Peoria ADMP study area, the floodplain and ***floodway*** are coincident due to the ***channel*** and floodplain geometry in the deep, narrow canyons, and the ***floodway*** modeling techniques used for the floodplain delineation studies. Therefore, in reaches where the ***floodway*** and floodplain are coincident, it is unlikely that any ***floodplain encroachment*** will occur. The majority of the wider ***floodway fringe*** areas in the study area occur on Caterpillar Tank Wash, Twin Buttes Wash, and the Twin Buttes Wash tributaries.

Where ***floodway fringe*** areas exist in the North Peoria ADMP study area, ***floodplain encroachment*** should be avoided except where it meets the low-impact criteria defined below. Encroachment that exceeds the low-impact criteria should be allowed only where it can be demonstrated that no long-term or short-term off-site impacts to ***channel*** stability occur, the encroachment is adequately protected from ***erosion*** and flooding, and a long-term maintenance and inspection program is adopted.

Low Impact Structural Alternative

For the purposes of the North Peoria ADMP, a "low-impact" development alternative is defined as any activity within the ***floodway fringe*** or ***erosion*** hazard zone that does not significantly alter the natural form and function of the ***watercourse***. The following standards are proposed to quantify the definition of "low impact":

- Minimal velocity increases.
  - The average 10-year velocity in the ***channel*** or overbank should not change (± 0.0 fps).
  - The average 100-year velocity in the ***channel*** or overbank should not change (increase or decrease) by more than 10 percent or one-foot per second (fps), whichever is less.
- Minimal water surface elevation increase.
  - The 10-year water surface elevation should not change (± 0.0 ft.).
  - The 100-year water surface elevation should not increase or decrease by more than 0.1-foot.
- Minimal disturbance of the main ***channel***.
  - No decrease in the bankfull width of the main ***channel***.
  - No excavation or deepening of the streambed in the main ***channel***.
  - No removal of bank vegetation. Where bank vegetation is temporarily disturbed by construction, it should be replaced, monitored for health, and irrigated if required to assure its survival.
  - No relocation of the low-flow ***channel*** within the floodplain.
- No offsite impacts.
  - No ***erosion***, ***sedimentation***, or flood impacts to adjacent properties without written permission of affected property owners.
  - Engineering and geomorphic analysis required to demonstrate no long-term, short-term, or 100-year off-site impacts.
- Preservation of natural landscape character and habitat within the floodplain.

Alternatives that exceed the standards listed above are not considered low-impact alternatives. Such alternatives may be acceptable methods of mitigating flood and ***erosion*** hazards, if properly engineered.

Examples of and design guidelines for a low-impact structural alternative are provided in the North Peoria ADMP, Technical Data Notebook, Attachment 3, Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums, Chapter 5.

Channelization

Channelization is defined as construction of an engineered ***channel*** with bank protection and grade control structures. Channelization is generally known to have the following impacts on ***channel*** stability:

- *Velocity*. Channelization generally increases ***channel*** velocities. Velocity is exponentially related to sediment transport rate and ***erosion*** potential.
- *Depth*. Channelization can increase the flow depth by eliminating the floodplain area available for conveyance. Increased depths result in greater ***scour*** depths and higher velocities.
- *Discharge*. Channelization eliminates the area available for storage of floodwaters on the floodplain, resulting in decreased attenuation and increased peak discharges downstream. Increased peak discharges are directly related to increased sediment transport rates and ***erosion***.

- *Design Standard.* Engineered flood control ***channels*** are typically designed to a 100-year standard. Therefore, damage may occur to development adjacent to a 100-year ***channel*** (or to the channelization itself) if flow rates greater than the 100-year event occur. If design discharges change due to watershed changes or revisions to hydrologic modeling standards, retrofit solutions are required to maintain the same standard of protection.

- *Design Life.* Engineered structures have a limited design life, and require regular maintenance and inspection, and eventual replacement.

- *Equilibrium Slope.* Because of the increase in discharge, velocity, and depth, the stable slope is generally flatter than the existing ***channel*** slope, which will cause long-term ***scour*** and require grade control to prevent undercutting of bank protection.

- *Habitat.* Channelization typically eliminates most of the natural floodplain and stream bank habitat, and requires mitigation measures.

- *Sediment Supply.* Bank ***erosion*** is an important source of sediment supply for the streams in the study area. Construction of bank protection eliminates this source of sediment, increasing the likelihood of ***erosion*** of adjacent and downstream reaches.

- *Downstream Impacts.* Excessive instability should be expected at the outlet of a channelized reach due to the changes in velocity, sediment supply, and discharge. Depending on the ***channel*** geometry, the expected response can range from lateral ***erosion*** and ***scour*** to sediment deposition and overbank flooding.

Channelization, a structural flood control measure, is not recommended as a development alternative in the North Peoria ADMP study area. Channelization should be allowed only where it can be demonstrated that no long-term or short-term off-site impacts to ***channel*** stability occur, that downstream reaches are adequately protected from ***erosion*** and flooding, and a long-term maintenance and inspection program is adopted. Where structural flood control measures are necessary, the design and installation of such structures should compliment the environment and be accomplished with the least disturbance to the natural setting. Design guidelines and standards for structural flood control improvements are provided in the Maricopa County Drainage Design Manual Volume II, Hydraulics and the City of Peoria Infrastructure Development Guidelines.

Roadway Crossing Drainage Structures

At-Grade Crossings

"At-grade crossings" typically have only minimal or localized impacts on ***channel*** stability. More commonly, the streams impact the at-grade crossing, rather than vice versa. Flow over the at-grade crossing can cause ***erosion*** of the pavement and subgrade, deposition of sediment in the road section, and disruption of traffic flow. Channel stability impacts commonly observed near "at-grade crossings" include the following including recommendations for mitigation:

Example of an "At-Grade Crossing"

- A ***scour*** hole often forms on the downstream side of an "at-grade crossing" due to acceleration of flow over the hydraulically smooth pavement surface and increased turbulence as flow transitions back at the natural ***channel*** bed. In most cases, formation of a ***scour*** hole doesn't impact stream reaches located far from the "at-grade crossing", however the development of a ***scour*** hole could undermine the "at-grade crossing", leading to failure of the facility. Upstream and downstream cut off walls shall be designed for at grade crossings.

- An "at-grade crossing" of a ***watercourse*** reach which is experiencing ***degradation*** will ultimately function as a grade control structure. Until equilibrium is achieved, down stream ***degradation*** will continue increasing the drop immediately downstream of the "at-grade crossing". Long term ***degradation*** shall be considered in determining the depth of cut off walls.

If the "at-grade crossing" is constructed at an elevation slightly above the natural ***channel*** bed, deposition will occur upstream of the crossing. Deposition leads to expansion of the floodplain, and may increase the risk of ***avulsions*** and accelerate formation of the downstream ***scour*** hole. The minimum elevation of an "at-grade crossing" shall not be higher than the existing ***channel*** invert.

"At-grade crossing" is not a recommended ***watercourse*** / roadway crossing in the City of Peoria.

Culverts

The design of culvert structures takes into consideration public safety, long term function and maintenance, and impacts to the natural ***channel*** form and function. Typically, the impact of culvert crossings on a ***watercourse*** system is primarily a function of their size in relationship to design discharge, natural ***channel*** and floodplain morphology, clogging potential, sediment transport capacity and ***scour*** potential.

Undersized (relative to natural ***channel*** and floodplain geometry) culverts and culverts that create headwater ponding can have detrimental impacts to both upstream and down stream properties. The impacts of undersized culverts on ***channel*** stability include the following including recommendations for mitigation:

- *Sediment Deposition*. Much of the stream's sediment load will be deposited in the headwater pool at the culvert inlet. The volume of sediment deposited depends on the culvert capacity relative to the discharge, the duration of the ponding condition, the geometry of the ponding area, and the size of the sediment in transport. Sediment deposition decreases ***channel*** (and culvert) capacity, increases the potential for overbank flooding and ***avulsions***, and requires maintenance to restore natural conditions. Culvert rise (height) at a minimum should be as high as the average main ***channel*** bank height. In the event of width and height limitations due to natural conditions, the structure does not convey the design event, increasing the height dimension or providing relief culvert structures in the overbank areas should be considered before increasing the width. Culverts that do not obstruct the main ***channel*** will have less frequent impacts on ***channel*** stability.

- ***Floodplain Encroachment***. A culvert is a form of ***floodplain encroachment***, with the same types of encroachment impacts described in the ***floodplain encroachment*** discussion above.

- *Scour Hole*. A ***scour*** hole may form at the culvert outlet due to accelerated velocity through the culvert, discharge of sediment-deprived water, and turbulence at the culvert / natural ***channel*** interface. Design of culvert structures shall include an evaluation of the ***scour*** potential at the outlet of the structure and provisions for ***channel*** protection at the outlet shall be provided.

- *Long-term* Degradation. Where a significant percentage of the sediment load is deposited upstream of a culvert due to headwater ponding, discharge of clear water may result in ***degradation*** downstream until the ***channel*** slope adjusts to the new sediment supply. Culverts shall be designed so that the disruptions to the natural sediment transport capabilities of the wash are minimized.

Example of Headwall Constructed of Native Material

Oversized (relative to natural ***channel*** and floodplain geometry) culverts structures, which increase the width of the natural ***channel*** in order to minimize the height or depth of ponding, can also have detrimental impacts to both upstream and down stream properties.

The impacts of oversized culverts on ***channel*** stability include the following:

- *Long-term* Aggradation. Increasing the natural width of a ***channel*** to accommodate a culvert structure would change the sediment transport capacity of the ***channel***. During frequent events or events lesser than the design capacity of the culvert structure sediment would be deposited in the section of ***channel*** that has been widened. Accumulation of sediment would decease both the capacity of the ***channel*** and the capacity of the structure ultimately resulting in flooding impacts to adjacent properties. Culvert span (width) should be as wide as the main ***channel*** (top of left bank to top of right bank) where ***channels*** are well defined. Culverts that do not obstruct the main ***channel*** will have less frequent impacts on ***channel*** stability than culverts that block the main ***channel***.

Bridges

Bridges that span the floodplain typically have no measurable impact on ***channel*** stability, as evidenced by the ***channel*** conditions observed at the Beardsley Canal flumes over Caterpillar Tank Wash and Twin Buttes Wash within the North Peoria ADMP study area. Bridges with narrow openings are functionally like a culvert, and have the impacts on ***channel*** stability described above.

Example of a Bridge Structure Clogged with Sediment

Based on their likely impacts on ***channel*** stability, the following guidelines for roadway crossing design are recommended for ***watercourses*** in the North Peoria ADMP study area:

- Bridges are preferable to culverts. Bridges typically have less impact on ***channel*** stability than culverts due to the wider opening and decreased likelihood of headwater ponding.

- Bridge span (width) at a minimum should be as wide as the ***channel*** or ***floodway*** limits, preferably as wide as the floodplain or ***erosion*** hazard zone where ***channels*** are well defined. Bridges that do not obstruct the main ***channel*** will have less frequent impacts on ***channel*** stability than culverts that block the main ***channel***.

- Where ***braided*** or multiple ***channels*** exist, relief structures outside of the main ***channel*** should be provided to maintain overbank flow paths, preserve overbank conveyance, and prevent floodplain ***sedimentation***; instead of widening one of the multiple ***channels*** to provide conveyance of the design event at one location.

- Bridge crossings should be regularly maintained and inspected to identify potential problems and impacts to ***channel*** stability, and to assure structure performance.

- The need for ***erosion*** protection should be evaluated at all bridge crossings of ***watercourses***.

Utility Crossings

Utility crossings, if properly constructed, have no inherent impact on ***channel*** stability since they are typically buried beneath the ***channel*** or extended overhead. Direct impacts on ***channel*** stability can occur during utility construction due to disturbance of bank and floodplain vegetation. Where vegetation is removed, the underlying soils are more vulnerable to ***erosion*** and ***scour***. If floods occur before the vegetation is reestablished, ***erosion*** of the construction alignment may occur and initiate ***erosion*** of adjacent ***channel*** reaches.

The following guidelines for utility construction in the floodplain and ***erosion*** hazard zone are recommended:

- Bank and floodplain vegetation removed or damaged during construction should be replaced immediately. Irrigation, inspection, and maintenance may be required to assure survival of the replacement vegetation.

- Underground utilities should be buried below the 100-year general ***scour*** depth in the main ***channel*** plus the long-term ***scour*** depth. Utility lines have been damaged due to exposure by long-term ***scour*** on numerous streams in Arizona.

- Where the potential for lateral movement exists, underground utilities should be buried at the same depth in the overbank areas or ***erosion*** hazard zone as in the main ***channel***, to prevent exposure after movement of the main ***channel***.

- Support structures for overhead utilities should not be located within the floodplain or ***erosion*** hazard zone. Where the length of the span requires that support structures be constructed within the floodplain or ***erosion*** hazard zone, the structures should be designed using the 100-year general ***scour*** plus long-term ***scour*** in the main ***channel*** burial depth. No structures should be placed in the main ***channel***.

Aesthetic Design Guidelines

Aesthetic guidelines are developed as a tool to be used by planners and designers to incorporate aesthetic quality into their design that is sensitive and consistent with the natural environment. As part of the North Peoria ADMP, landscape character themes are developed that could be incorporated into the design of flood control management alternatives. Specific themes developed are a Mountain Theme with a Mining Theme Overlay, and a Plains Theme with a Native American or Ranching Theme Overlay. Design guidelines and examples are present in the North Peoria ADMP, Technical Data Notebook, Attachment 4, Landscape Character and Visual Assessment Report. The following general design guidelines are offered:

Structural Erosion Protection Measures

Structural ***erosion*** protection measures can consist of a variety of engineered materials. Most common types of engineered materials used in Maricopa County are rock filled wire baskets (***gabion mattress***, Reno ***Mattress***), ***gunite*** and ***soil cement***. Structural ***erosion*** protection measures could be aesthetically enhanced by designing them to blend in color, texture and form with the surrounding environment and desired landscape character theme. Treatments include selection of material to provide the desired color and texture, artificially coloring material, and treatment of freshly excavated native material with Eonite or a similar aging product.

Channels

Channel alignments and side slopes should be consistent with natural ***channels*** in the area. Alignments should be sinuous and side slopes should vary in the angle of slope.

Drainage Structures

Landscape character themes could be incorporated into the design of bridge and culvert headwalls. **Figure 22** and **Figure 23** depict some possible landscape character themes that could be incorporated into a roadway drainage structure.

MAINTENANCE PLAN

A maintenance plan shall be developed for all structural type improvements. The plan will document required maintenance to be provided by the owner/owners of structural type drainage improvements. The plan shall include the following discussions as applicable:

- Type of facility.
- Owner of facility.
- Required maintenance activity.
- Vegetation maintenance.
- Bank protection maintenance.
- Grade control maintenance.
- Removal of debris and sediment from structures.
- Required permits for maintenance activity.
- Required inspection/monitoring activity.
- Schedule for inspection and monitoring activity.
- Required agency notification.

MAINTENANCE PLAN

The North Peoria ADMP presents ***watercourse*** and stormwater storage flood control management alternatives. For this plan to be successful, a monitoring and maintenance plan is required that address the overall non-structural goals as well as the specific elements of potential structural and low-impact structural measures. The maintenance plan establishes monitoring and maintenance criteria and inspection time frames that should be implemented to sustain the goals of the plan. The maintenance plan is presented in the North Peoria ADMP Technical Data Notebook.

CONSIDERATIONS FOR EXISTING STRUCTURES IN FLOOD HAZARD AREAS

GENERAL

Within the North Peoria ADMP study area, one permanent residential structure was identified within a flood and ***erosion*** hazard zone. The structure is located within Unincorporated Maricopa County, approximately 0.6 miles north of Happy Valley Road along 115th Avenue alignment in the Twin Buttes Wash ***floodway***. Flood Insurance Study work maps [Flood Insurance Study for Caterpillar Tank and Twin Buttes Washes From Agua Fria River to CAP Canal Maricopa County, Arizona, (Flood Control District of Maricopa County, 1991)] indicate that the structure was built prior to the original floodplain delineation of Twin Buttes Wash.

As part of the North Peoria ADMP, ***channel*** improvements that would mitigate impacts to the alignment of 115th Avenue and to the residential structure from a 100-year runoff event were evaluated. Improvements evaluated consist of a ***channel***, side slope protection consisting of rock-filled wire-tied baskets and an 11 cell 10-foot by 4-foot concrete box culvert. The cost estimate for construction of the ***channel*** improvements (not including land costs) is estimated at $1,299,137.

Currently Maricopa County has no capital improvement plans to provide roadway/***channel*** improvements along the 115th alignment between Happy Valley and Jomax Roads. City of Peoria personal related that should the City of Peoria annex the area, any improvements would be funded through an improvement district. There are plans being developed for the Estrella Roadway, which will cross the alignment of 115th Avenue, and Twin Buttes Wash approximately 1000 feet downstream of the subject structure, however there are no improvements proposed that would mitigate flooding to the structure or to the alignment of 115th Avenue.

OPTIONS

Under current Maricopa County floodplain regulations the existing structure could not be rebuilt if, due to flooding, fire, or some other catastrophic event, the structure suffered damages of greater than 50 percent of its appraised value. In addition, the current or future owners could not obtain building permits for new structures. A possible option to address the problem is to recommend the property be considered for a voluntary acquisition or on-site relocation program managed by the District. If the home qualifies for the program, the homeowner would have the option of selling their parcel to the District and having the structure removed from the site so that the land could return to its natural or near natural state or, if there are areas of the parcel outside the ***floodway*** and ***erosion*** hazard zone, and the homeowner wishes to move their home, the homeowner would have the option of relocating the residence on-site, but outside the high hazard areas.

Glossary

100-year storm
A rainfall event that has a 1% chance of occurring or being exceeded in any given year.

aggradation
A rise in the channel bottom elevation due to an accumulation of sediment over time.

avulsion
An avulsion occurs when a watercourse channel migrates laterally to another position within the natural floodplain. Lateral channel migration and head cutting are contributing elements to the avulsion process.

braided
A braided watercourse is one flowing in several dividing and reuniting channels resembling the stands of a braid. Avulsion and lateral migration processes contribute to the development of a braided watercourse.

channel
The deepest portion of a watercourse through which the majority of runoff is conveyed. Braided watercourses will have multiple channels.

computer models
Computer models developed as part of this study are developed to model hydrologic and hydraulic conditions. The models simulate a storm event (such as the ***100-year storm***) and estimates how much runoff will be generated from a given area (hydrology) and how deep and fast the runoff will move (hydraulics) within a watercourse draining the given area.

degradation
A deepening of a channel over time or in a single storm event due to erosion processes.

ephemeral watercourse
A watercourse or potion of a watercourse that flows only in direct response to rainfall.

erosion
The group of processes whereby rock and / or sediment deposits are loosened and / or dissolved and removed from their original locations.

existing conditions
Physical conditions within a watershed or watercourse at the time of evaluation.

100-year floodplain
A special flood hazard zone that is defined by the area along a wash that gets wet and carries water during a 100-year flood. Criterion to define the 100-year floodplain is established by the FEMA.

floodway
The floodway is that portion of the floodplain reserved by FEMA for the conveyance of floodwaters during a 100-year flood. Buildings and / or structures that would obstruct flow are not allowed within the floodway boundaries.

floodway fringe
The floodway fringe is the portion of the 100-year floodplain located adjacent too and outside of the FEMA 100-year floodway. Under FEMA regulations development within the floodway fringe is permissible providing certain criteria are met.

floodplain encroachment
Floodplain encroachment is defined by development activity that occurs within the floodway fringe. The collective impact of the development activity can not increase the 100-year water surface elevation over FEMA 100-year floodway water surface elevations. Floodway water surface elevations are up to one foot higher than floodplain elevations.

future conditions
For this study future condition is the proposed physical condition of the watershed based on the City of Peoria’s General Plan.

gabion mattress
A gabion mattress is a structural form of erosion protection. A gabion mattress consists of wire baskets filled with rock.

geomorphology
The study of landforms and the physical processes that form the land surface.

gunite
A structural bank / channel stabilization measure consisting of cement, sand and water.

hydraulics
For purpose of this study, hydraulics is how stormwater moves through a watercourse. Through hydraulic evaluations, depth, velocity, width and energy of stormwater flow within a watercourse are estimated.

hydrology
For the purpose of this study, hydrology is the estimation of the magnitude of runoff from a rainfall event within a given watershed. Typically runoff is that portion of rainfall that does not instormwaterfiltrate into the soil.

lateral channel migration
The horizontal movement of a channel within the natural floodplain by erosive processes defines lateral channel migration.

paleoflood
A flood event at a given time in the geologic past.riparian

perennial flow
Watercourses or a portion of watercourses that flow year around.

scour
Erosion due to the mechanical process of water removing earthen material from a channel bottom or banks.

sedimentation
The natural process of flowing waters depositing soil, sand, gravel, cobbles and boulders within a channel and associated natural floodplain.

soil cement
A type of structural channel stabilization consisting of cement and native materials.

watercourse
For the purpose of this study a watercourse is defined as a natural drainage way defined by the 100-year floodplain limits and the erosion hazard zone.

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NORTH PEORIA AREA DRAINAGE MASTER PLAN

FIGURE 2

LOCATION AND PHYSICAL CHARACTERISTICS

- Incised sinuous wash
- Channel bottom consists of sand and gravel and is typically lined with vegetation Vertical cut banks and rock
- bottoms are typical throughout the reach Natural stream grade controls
- occur throughout the reach

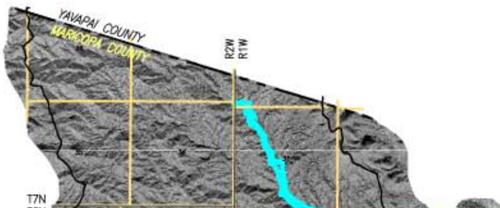
- Lower reach is characterized by a riparian forest area
- Incised sinuous wash
- Channel banks are steep
- Natural stream grade controls occur throughout the reach
- Vegetation lined banks

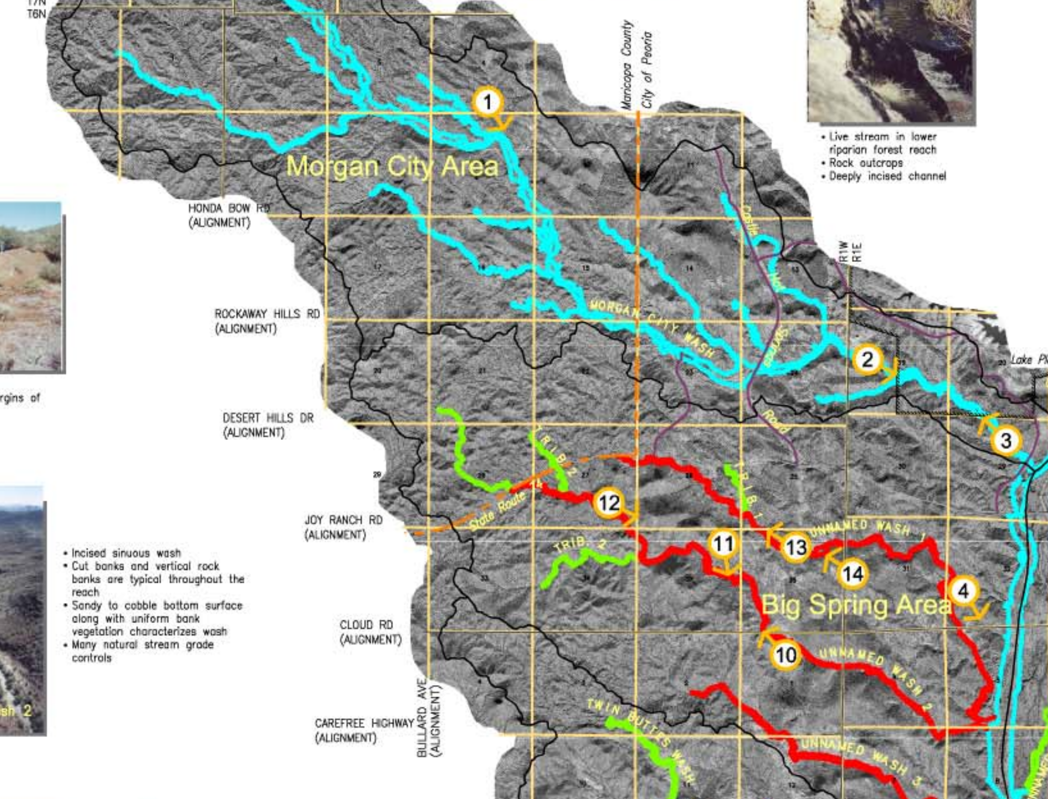
- Live stream in lower riparian forest reach
- Rock outcrops
- Deeply incised channel

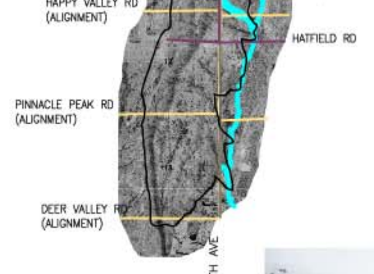
- Well defined incised wash
- Rock outcrops
- Channel bottom consists of sand, gravel, cobbles and boulders
- Uniform vegetation cover at the margins of the wash
- Many natural stream grade controls

- Stock tank
- Dense vegetation cover at margins of impoundment area

- Incised sinuous wash
- Cut banks and vertical rock banks are typical throughout the reach
- Sandy to cobble bottom surface along with uniform bank vegetation characterizes wash
- Many natural stream grade controls







- Dense vegetation along banks
- Landform vistas

- Petroglyph
- Vertical rock bank

- Incised sinuous washes defined by vegetation corridors

- Deeply incised channel
- Rock outcrop
- Natural grade control

- Vegetation lined banks
- Channel bottom width varies
- Channels are typically cut into alluvial material consisting of sand, gravel and cobbles

- Vegetation lined banks
- Landform vistas
- Channels are typically cut into alluvial material consisting of sand, gravel and cobbles

- Cultural resource site

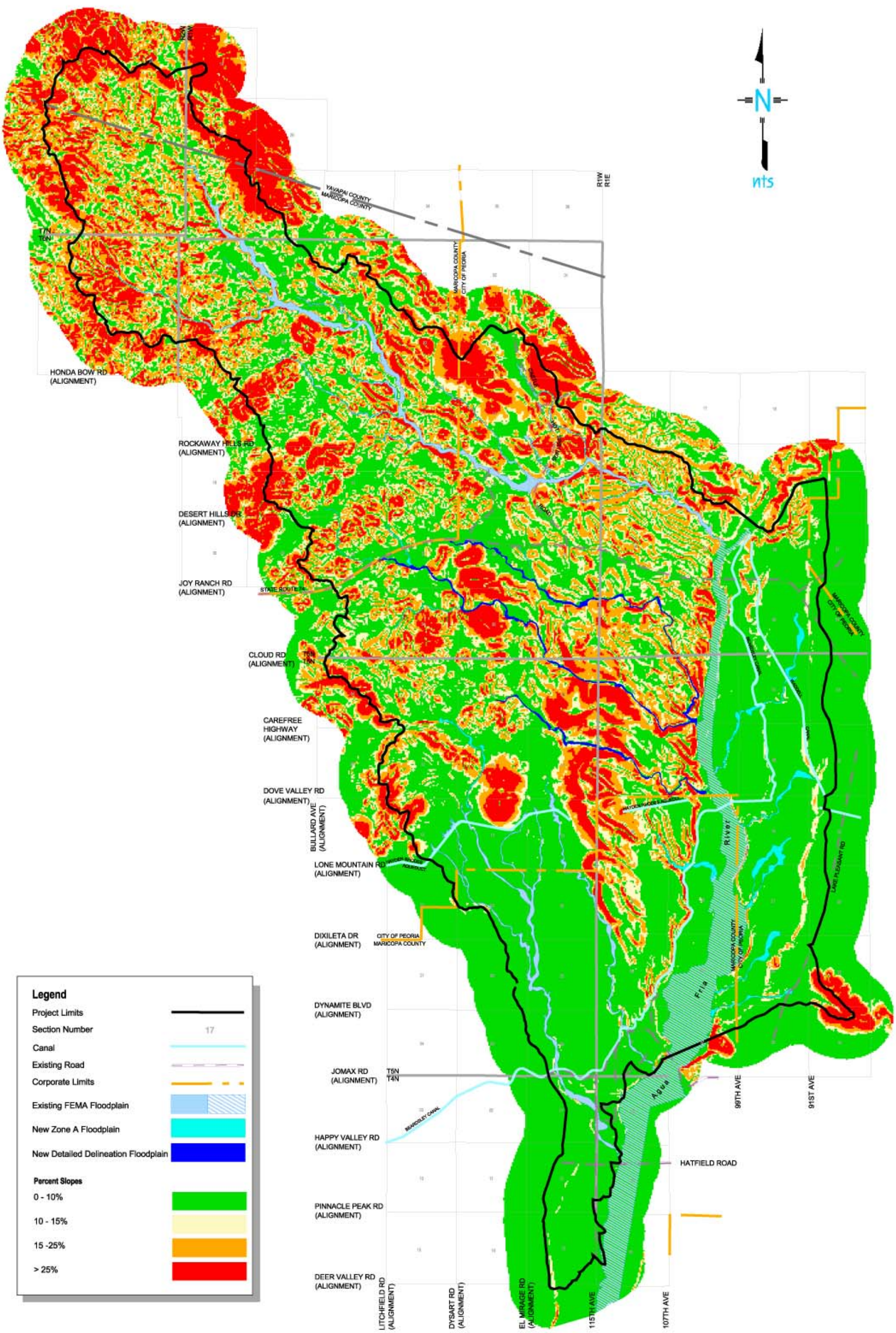
- Spring flowers

Legend

- Plan Area Boundary
- Effective FEMA Floodplain
- Detailed Delineated Floodplain (this study)
- Zone A Floodplain (this study)
- Corporate Limits
- Photo Location

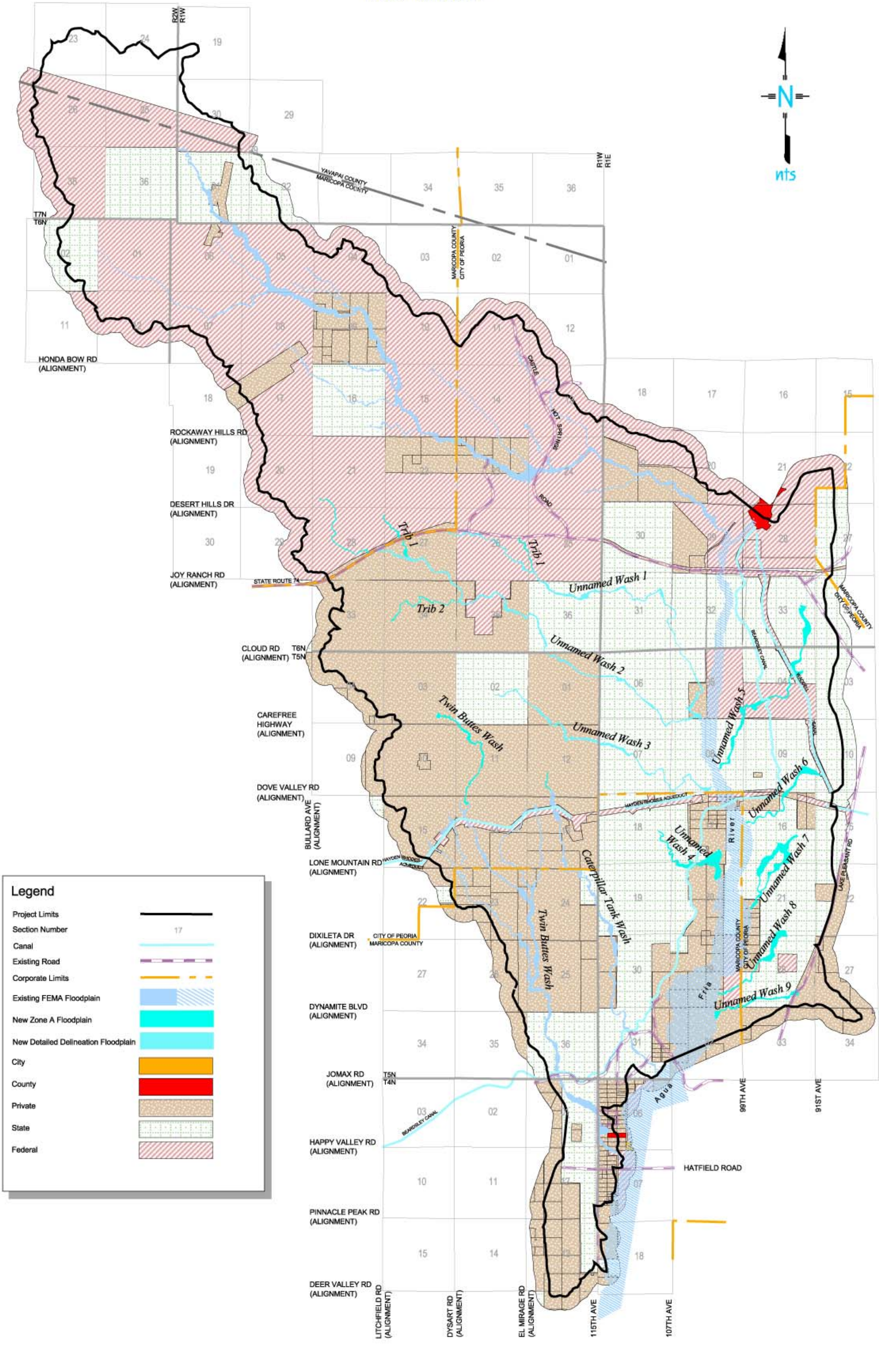
NORTH PEORIA AREA DRAINAGE MASTER PLAN

FIGURE 3
TERRAIN SLOPE



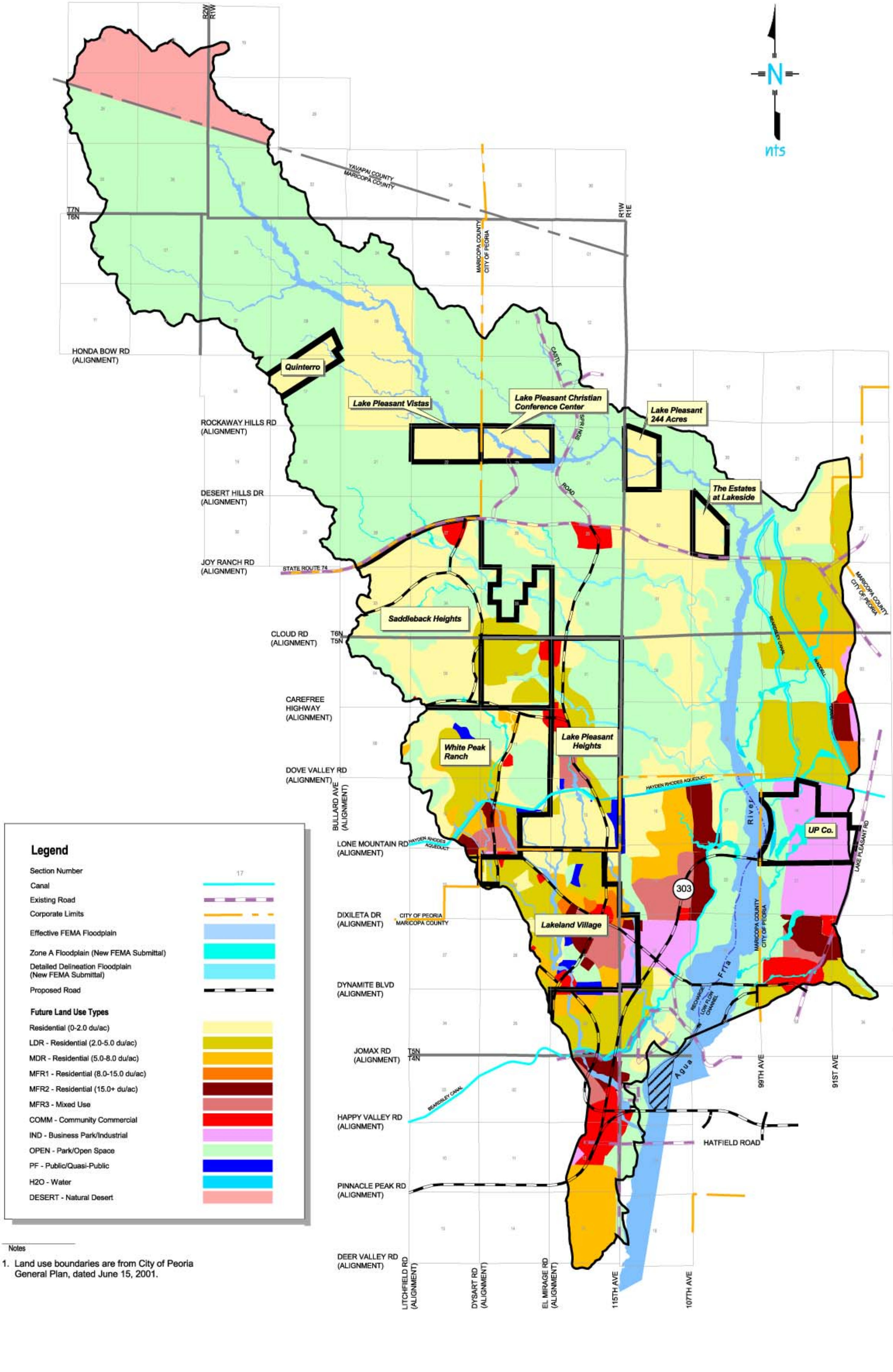
North Peoria Area Drainage Master Plan

Figure 4
Land Ownership



NORTH PEORIA AREA DRAINAGE MASTER PLAN

FIGURE 5
FUTURE CONDITIONS CONSTRAINTS



Notes

1. Land use boundaries are from City of Peoria General Plan, dated June 15, 2001.

Figure 6
Watershed Map

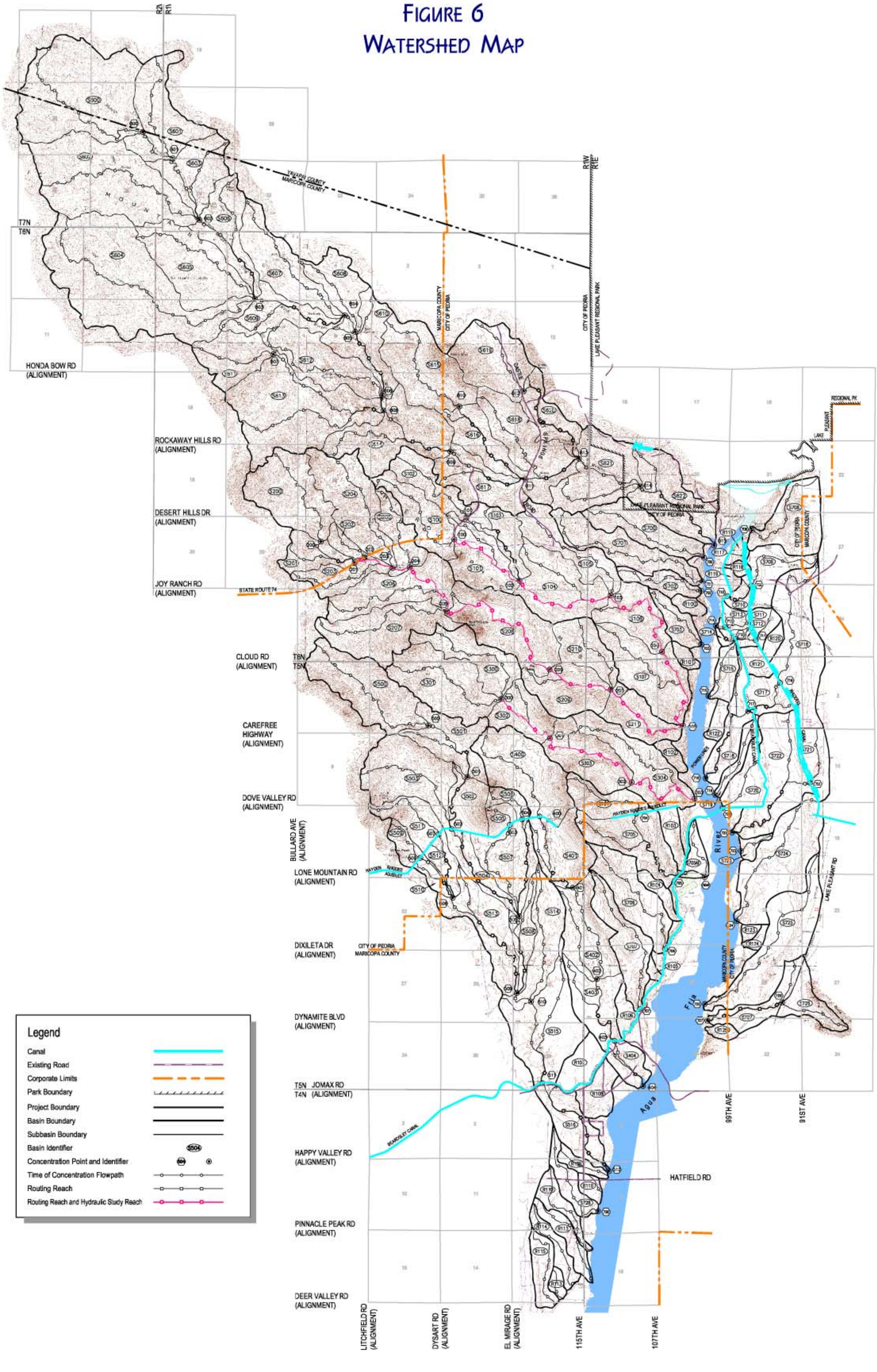


FIGURE 7
FLOOD PLAINS /EROSION HAZARD ZONES MORGAN CITY AREA

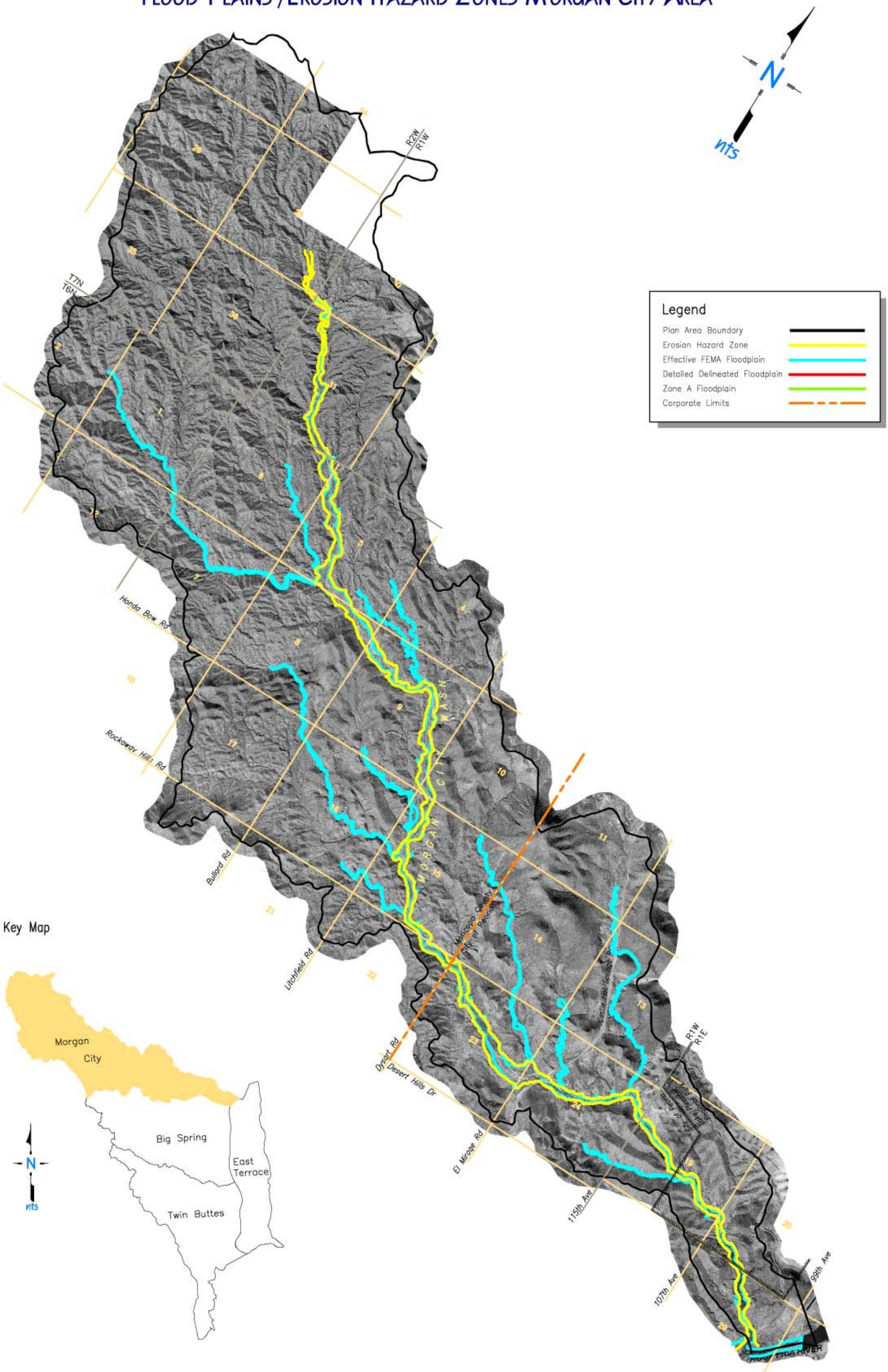


FIGURE 8
FLOOD PLAINS / EROSION HAZARD ZONES BIG SPRING AREA

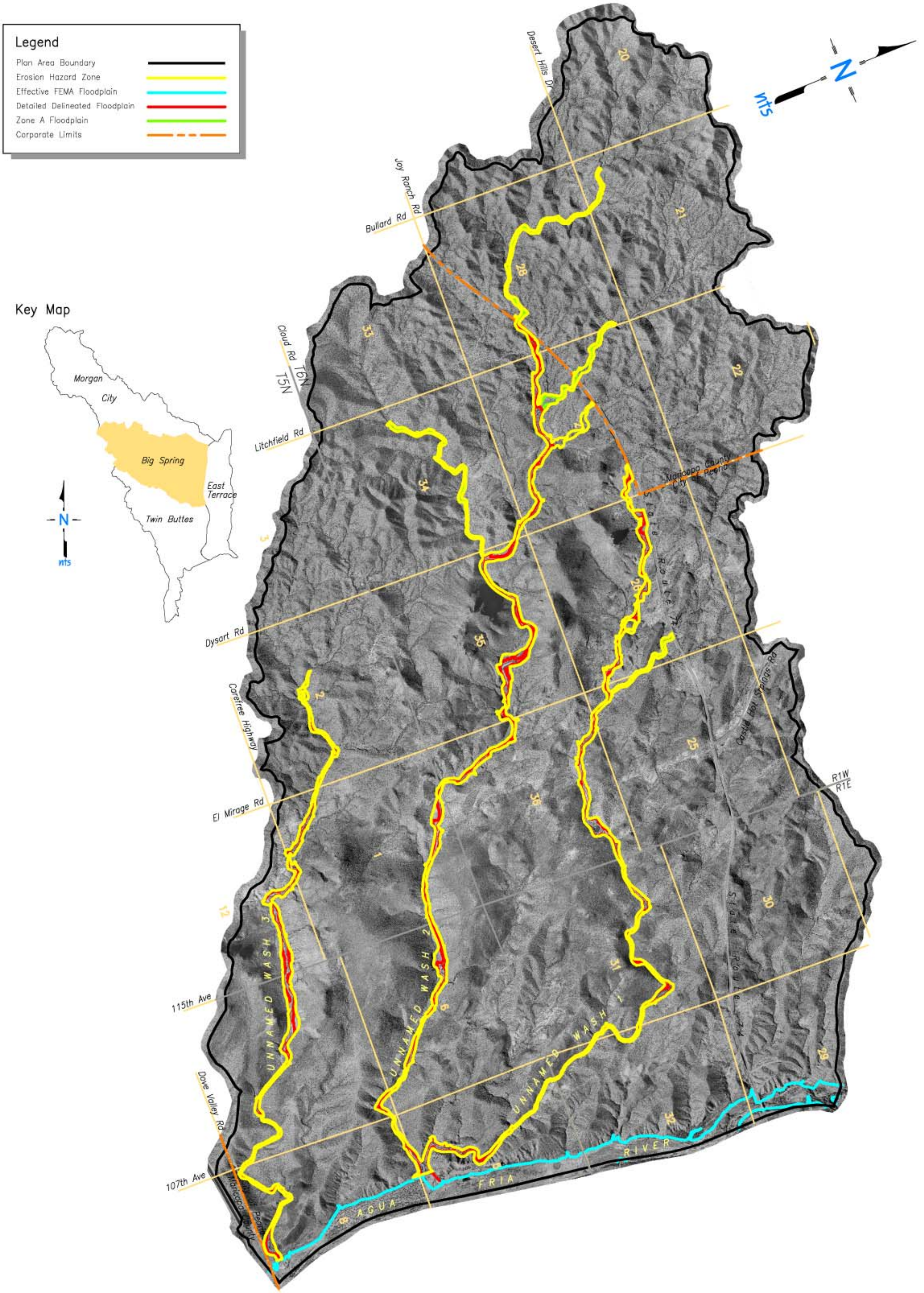


FIGURE 9
FLOOD PLAINS /EROSION HAZARD ZONES TWIN BUTTES AREA

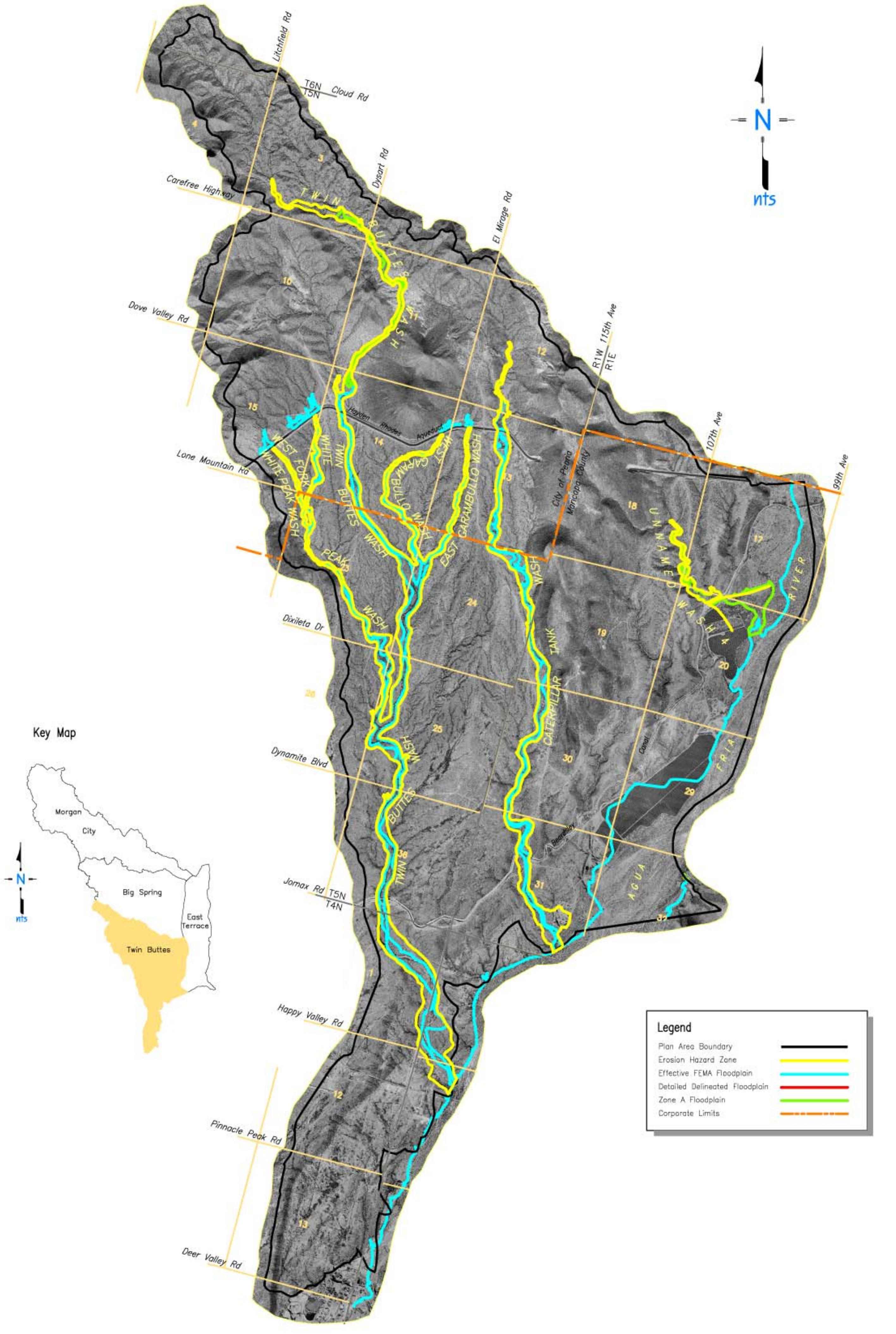
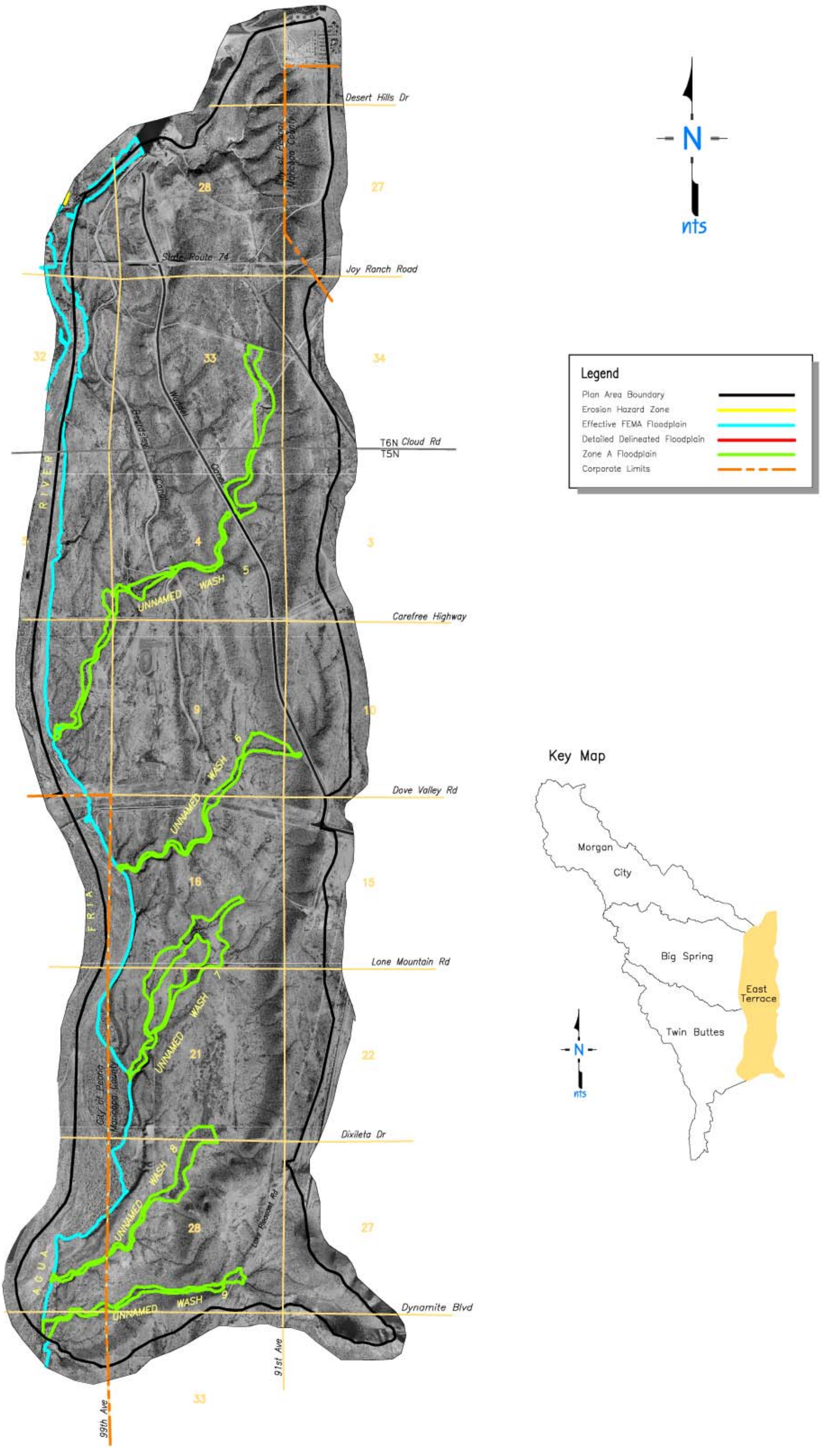
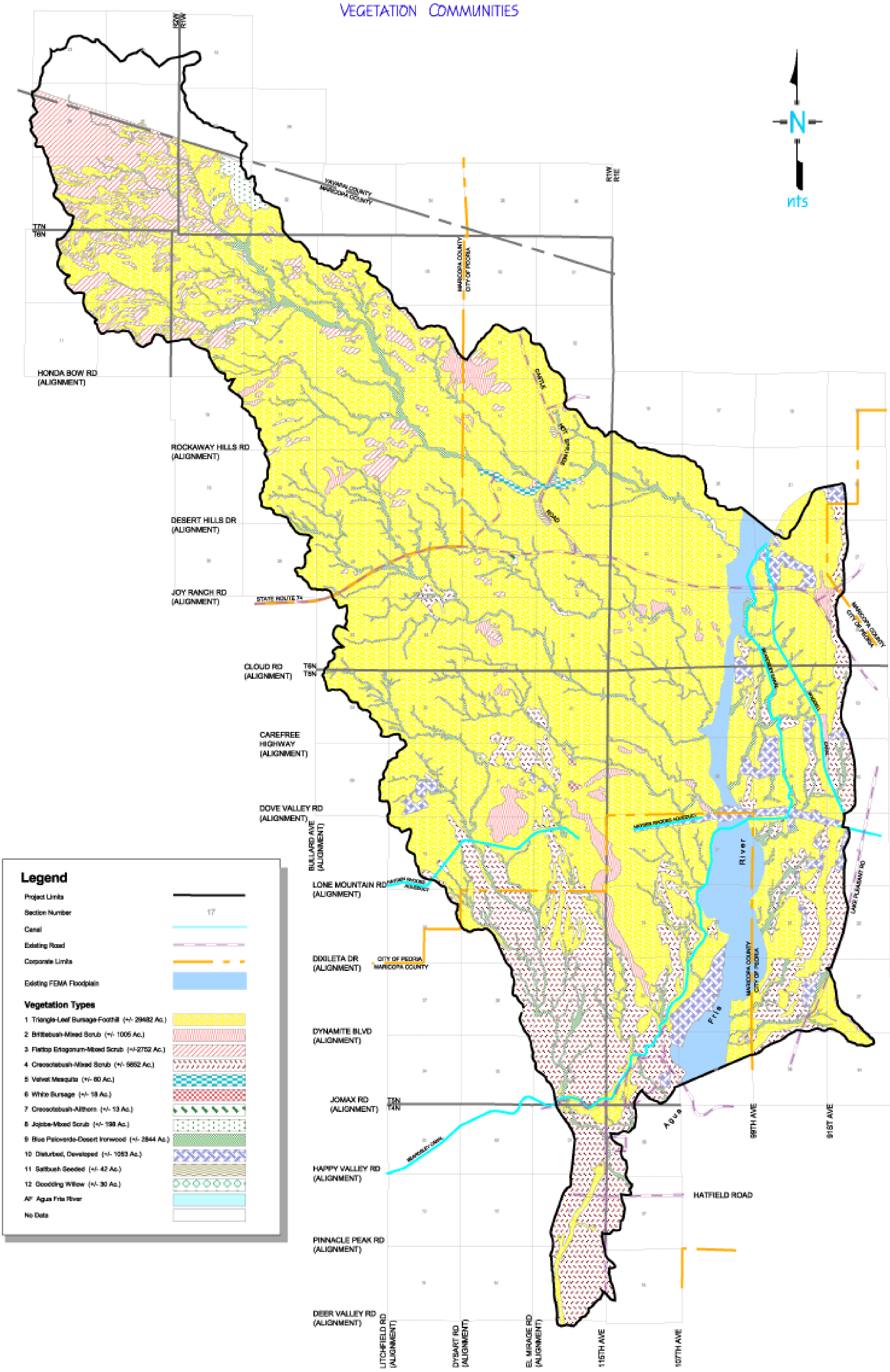


Figure 10
Flood Plains / Erosion Hazard Zones East Terrace Area



North Peoria Area Drainage Master Plan

Figure 11
Vegetation Communities



NORTH PEORIA AREA DRAINAGE MASTER PLAN

FIGURE 12
KNOWN CULTURAL RESOURCES

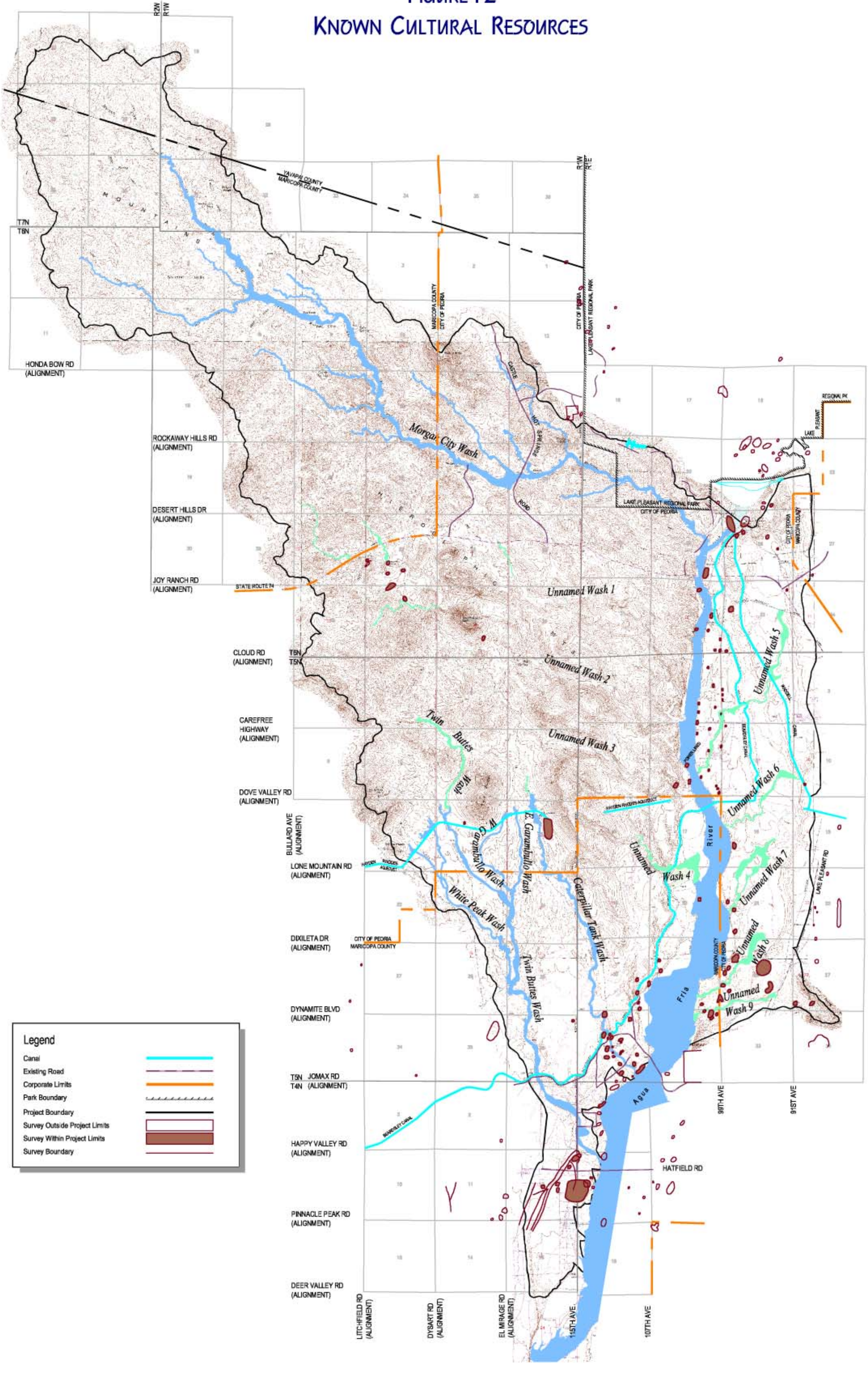


Figure 13
Scenic Attractiveness

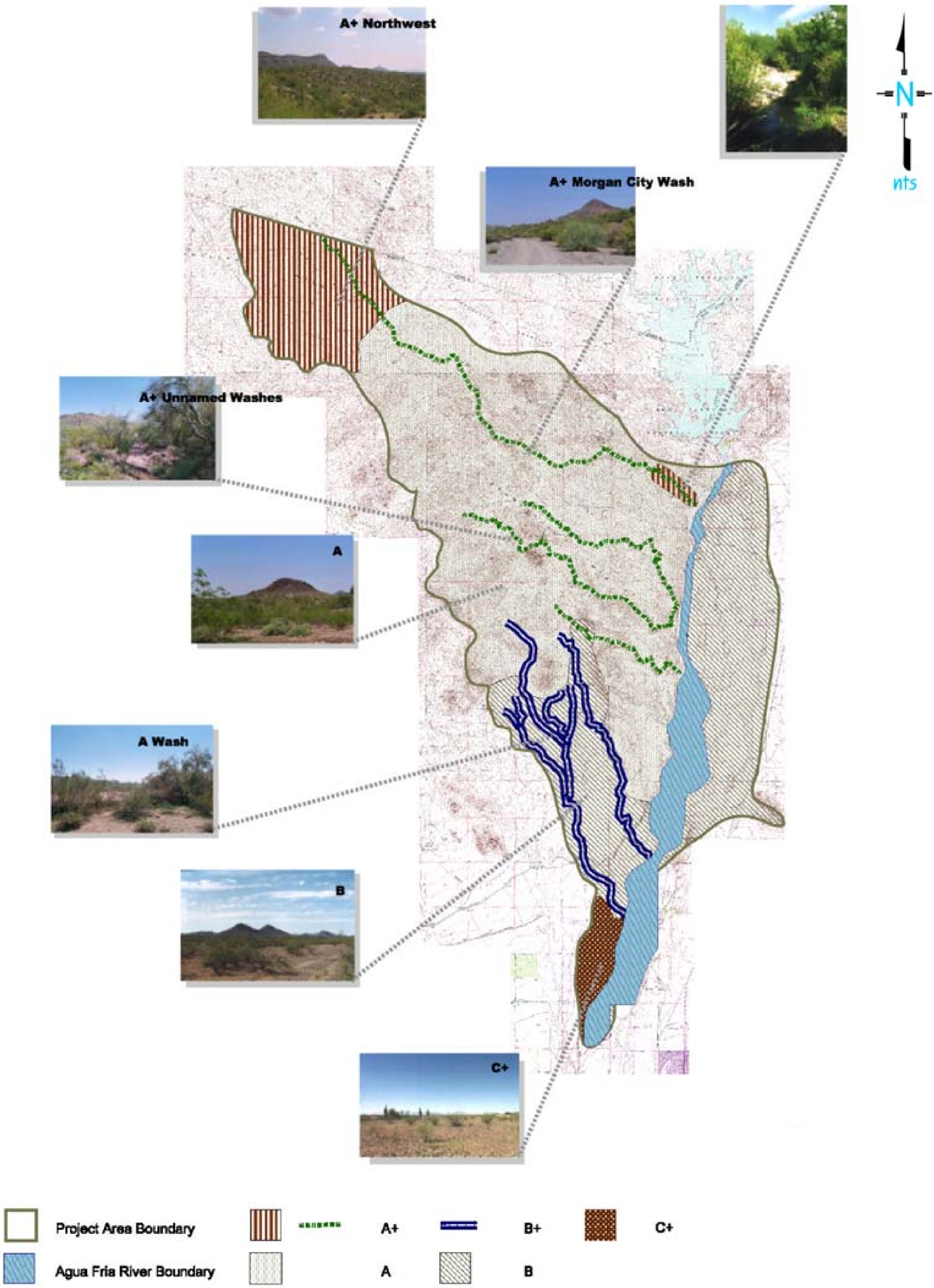
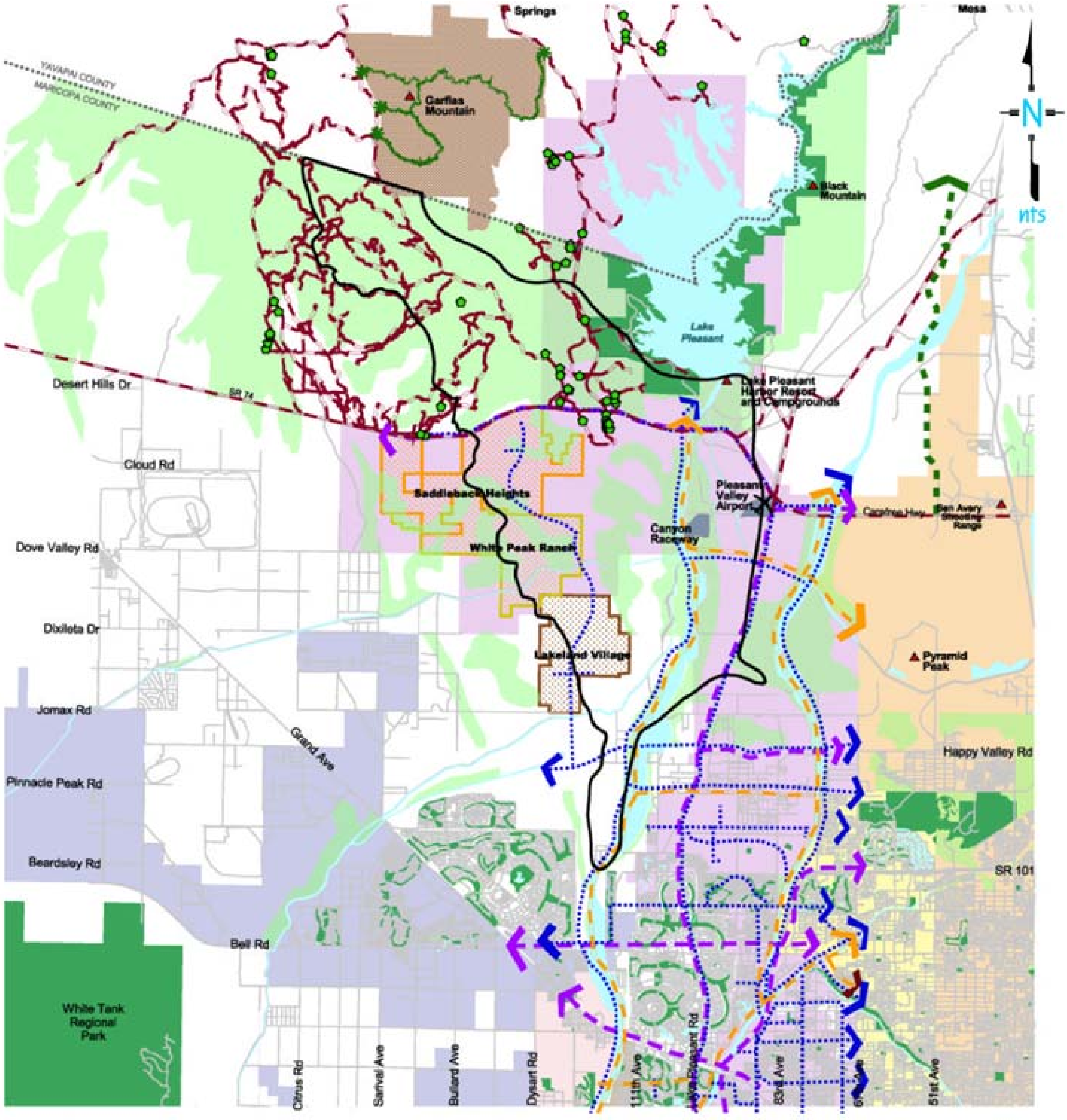


FIGURE 14
RECREATIONAL REGIONAL CONTEXT



Study Area	Recreational Open Space	Black Canyon Trail
County	Planned Recreational Open Space	BLM Non-Motorized Trails
Peoria	Hells Canyon Wilderness	BLM Access Guide Routes
Phoenix	Rivers, Canals and Washes	Multi-Use Trail
Glendale	Resource Area	Equestrian Trail
Surprise	Campsite	Bike Route
El Mirage	Trailhead	
Youngtown		

FIGURE 15
MULTIPLE USE OPPORTUNITIES

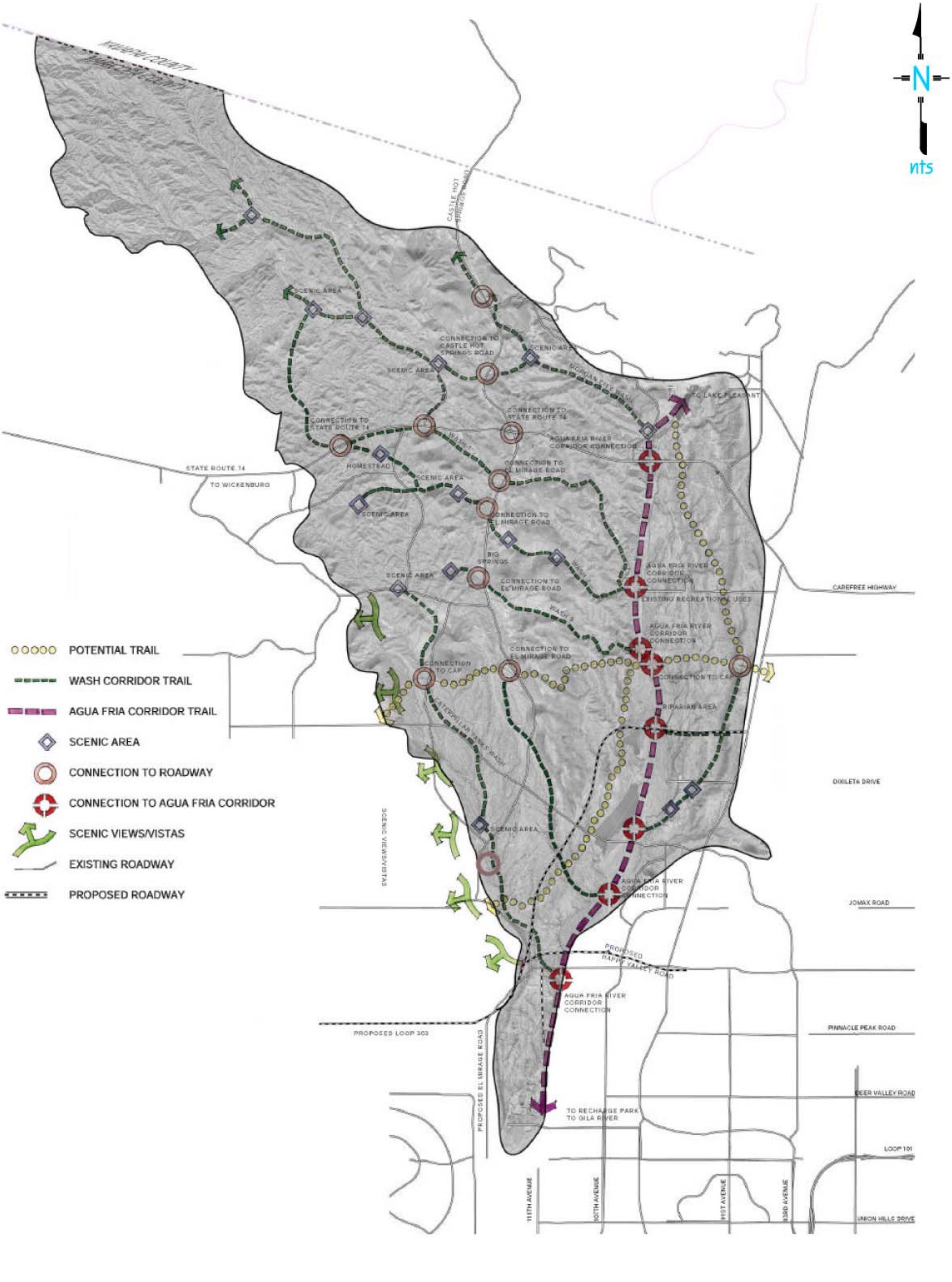


Figure 16
Non-Structural Alternative

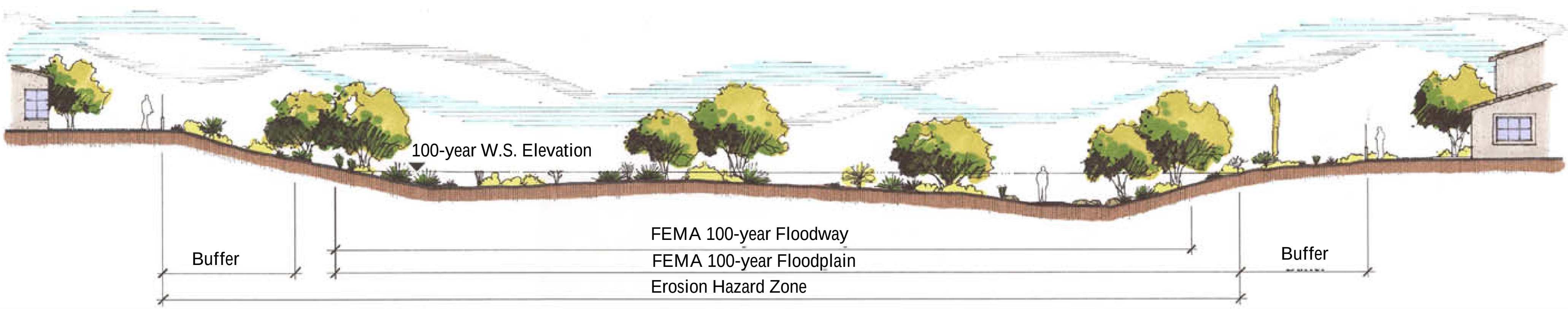


Figure 17
Low Impact Structural Alternative

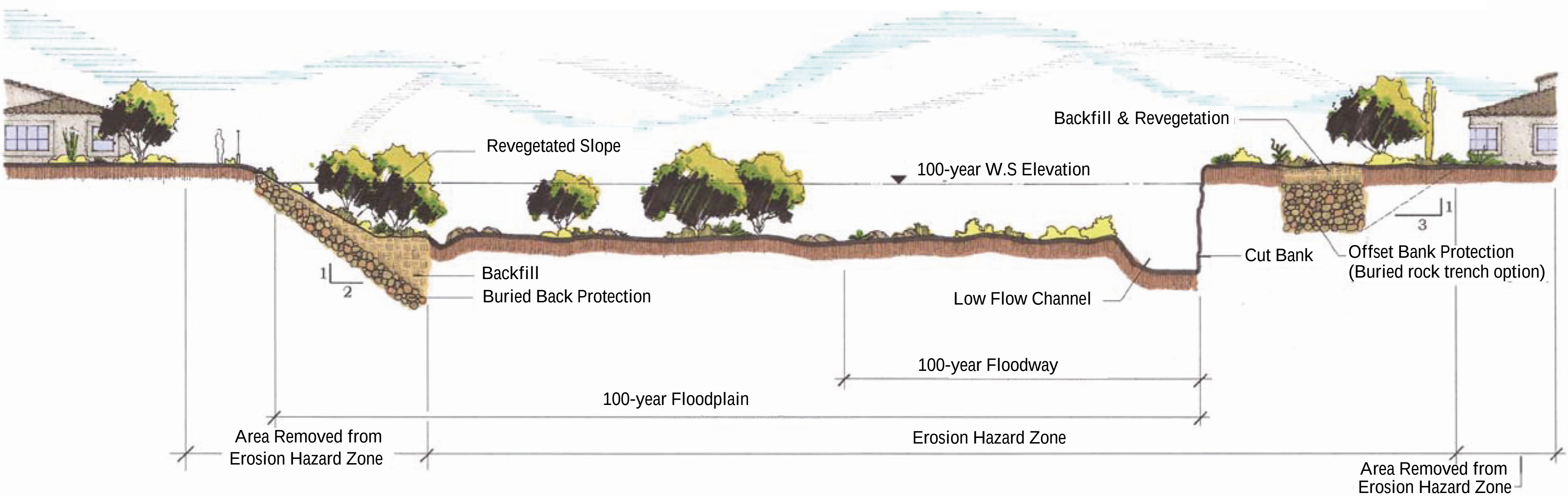


Figure 18
Partial Structural Alternative

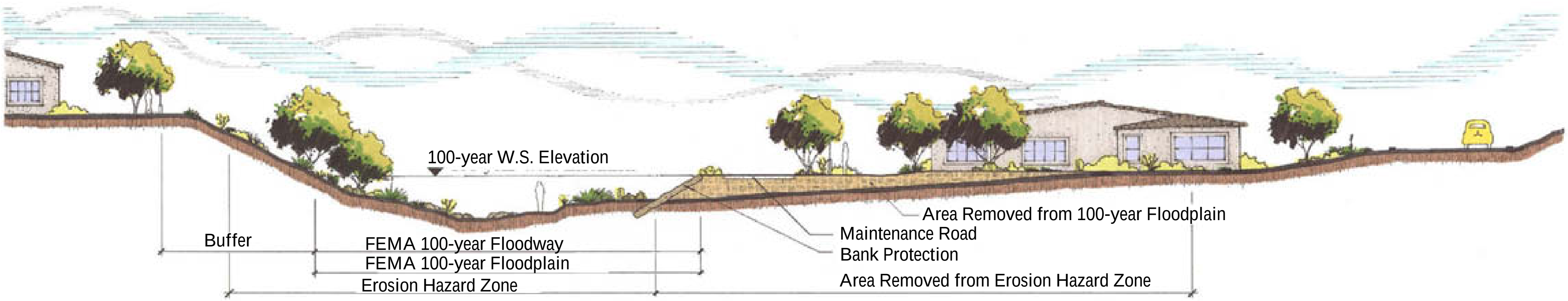


Figure 19
Full Structural Alternative

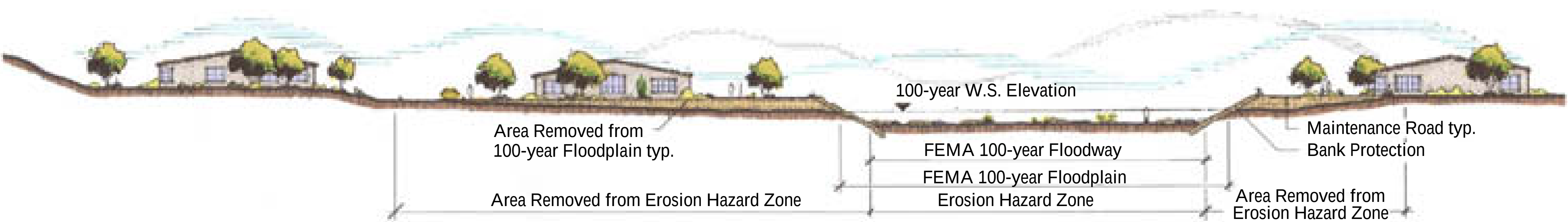


Figure 20

In-Stream, In-Line Detention

Figure 21
In-Stream, Off-Line Retention

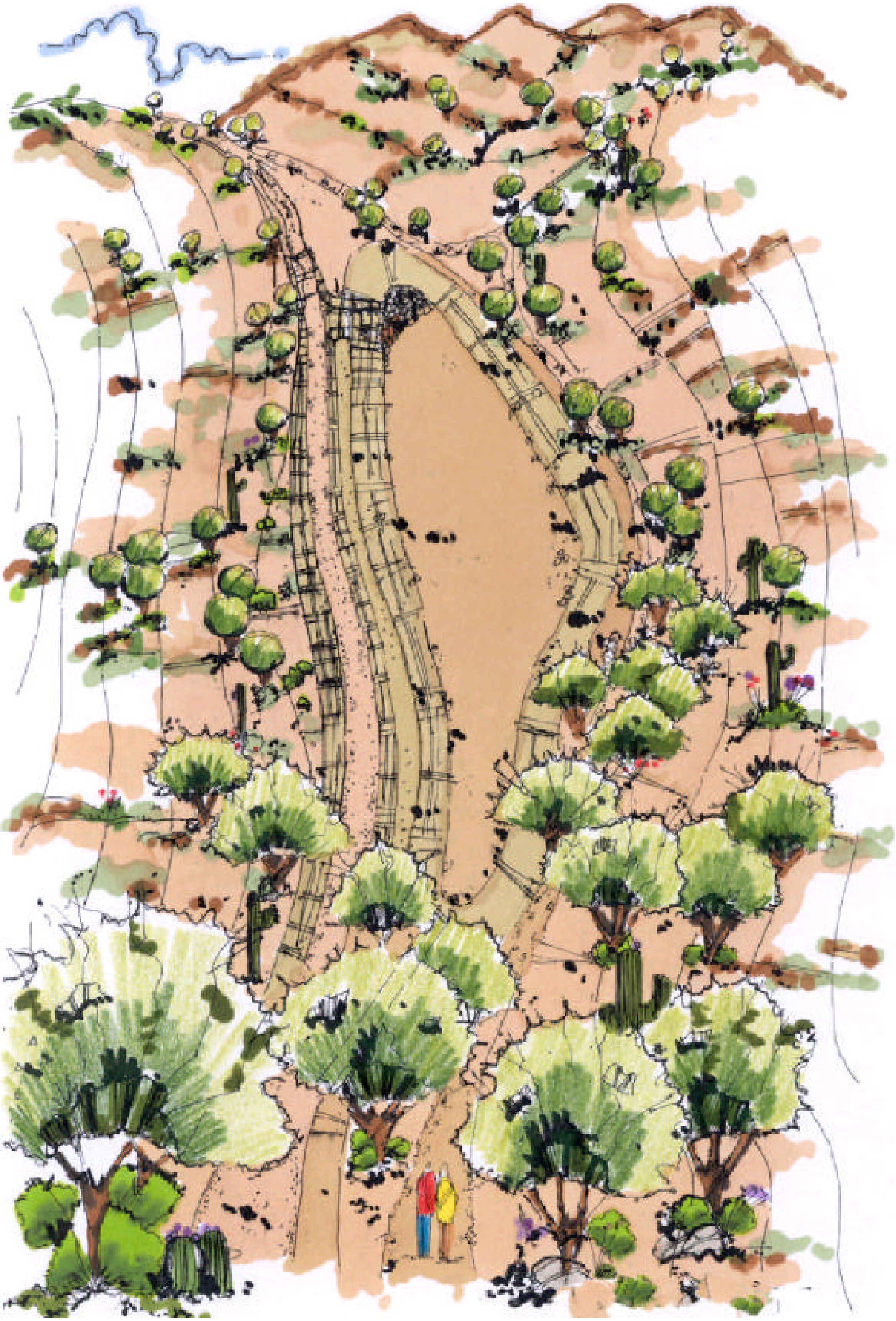


Figure 22
Headwall with Mining Theme

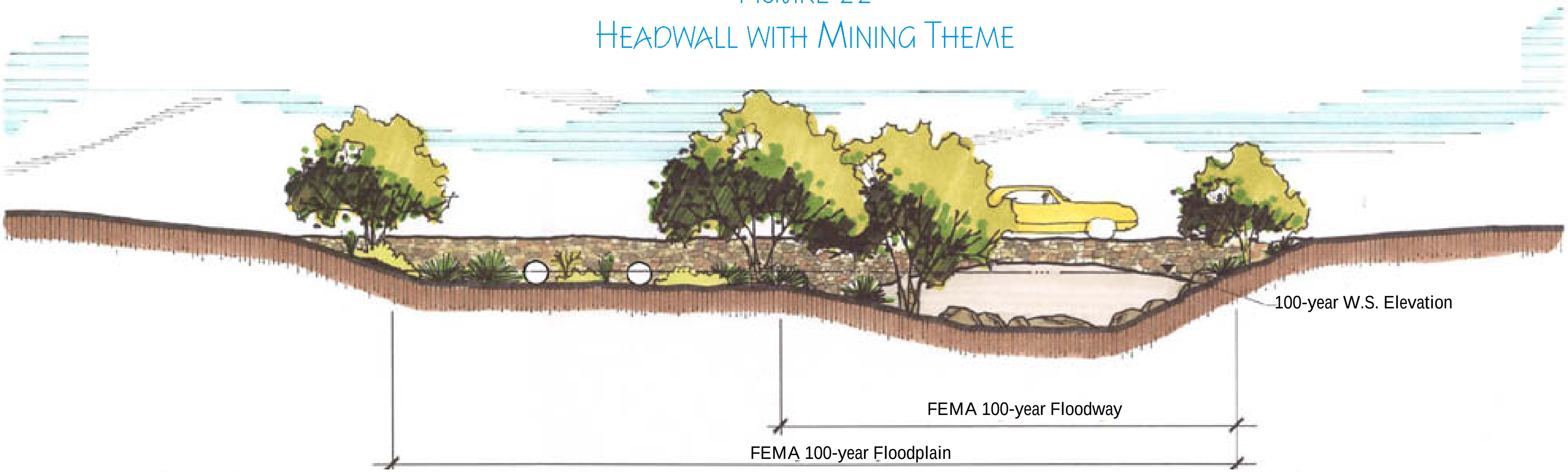
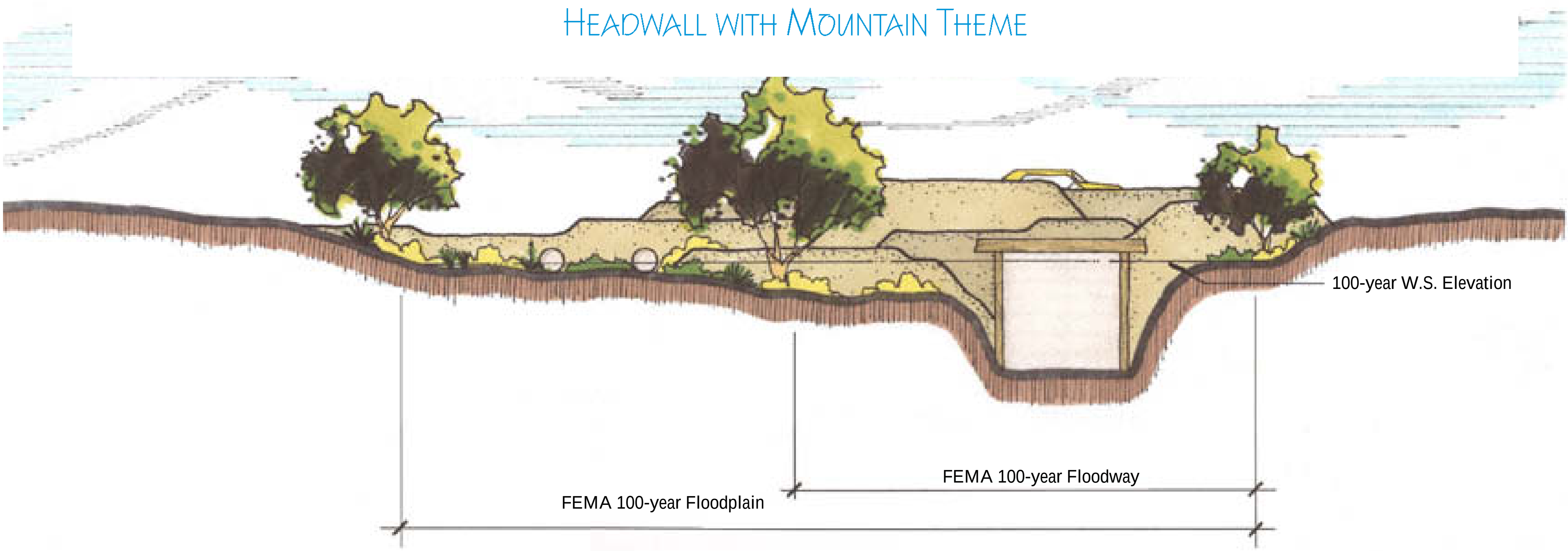


Figure 23
Headwall with Mountain Theme



North Peoria
Area Drainage
Master Plan

Prepared by

Stantec

Stantec Consulting
Southwest Regional Headquarters
8211 South 48th Street
Phoenix, AZ 85044
Tel: (602) 438-2200
Fax: (602) 438-9562

other offices located throughout North America

stantec.com

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